

SOLUTIONS MANUAL

TO ACCOMPANY

INTRODUCTION TO COLLEGE CHEMISTRY

FIFTH EDITION



ROBERT C. BUCKLEY

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Hillsborough Community College

TAMPA, FLORIDA

HOUGHTON MIFFLIN COMPANY BOSTON NEW YORK

Custom Publishing Editor: Kyle Henderson
Custom Publishing Production Manager: Kathleen McCourt
Custom Publishing Project Coordinator: Katie Meyer

This work was produced by Houghton Mifflin Custom Publishing and contains material not subject to Houghton Mifflin Company editorial review. The author is responsible for editing, accuracy, and content.

Cover Designer: Joel Gendron

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Printed in the United States of America.

ISBN-13: 978-0-618-24301-3
ISBN-10: 0-618-24301-1

N00834

3 4 5 6 7 8 9 – CCI – 09 08 07

Houghton Mifflin
Custom Publishing

222 Berkeley Street • Boston, MA 02116

Address all correspondence and order information to the above address.

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TO THE STUDENT: HOW TO USE THIS MANUAL

This "Solutions Manual" is designed to support the textbook "Introduction to College Chemistry," 4th ed. by Drew Wolfe.

This manual only addresses those answers to exercises that are indicated by **bold numbers** at the end of each chapter in the textbook. Solutions are provided in this manual for the answers appearing in Appendix D. The answers not in Appendix D are also provided in this manual.

The factor-label method described in Section 2.3 of the textbook is used whenever possible to solve numerical exercises. In many instances, hints and/or directions are given to get the student started on the solution to a difficult problem. These solutions should be treated as a last resort, and consulted only after honest efforts have failed to produce a satisfactory solution. If an exercise cannot be solved, and the solution is not given, the solution to a similar exercise should be consulted for guidance.

Remember that in many cases, several methods can result in the correct answer. If your answer disagrees with the one in the textbook or "Solutions Manual" only in the last digit, the solution is probably correct. The difference most likely results from the method used to round off atomic masses or constants.

CHAPTER TWO

PROBLEM SOLVING IN CHEMISTRY

2.17 (a) An observed color is a fact.
(b) A fact, or could also be considered a theory.
(c) This is a model based on evidence that has been discovered. It can not be tested by experiments but can be used to explain what has been found. Like all theories, it should not be considered as being right or wrong, but rather as useful.
(d) fact (e) theory (f) theory (g) law

2.20 (a) What is unknown? Number of miles traveled
What is known? 47 miles/1 gallon, 12 gallons

$$12 \text{ gallons} \times \frac{47 \text{ miles}}{1 \text{ gallon}} = 564 \text{ miles}$$

(b) What is unknown? Number of gallons
What in known? 164.5 miles, 47 miles/1 gallon

$$164.5 \text{ miles} \times \frac{1 \text{ gallon}}{47 \text{ miles}} = 3.5 \text{ gallons}$$

2.21 (a) What is unknown? Number of seconds
What is known? 8 minutes, 60 seconds/1 minute

$$8 \text{ minutes} \times \frac{60 \text{ seconds}}{1 \text{ minute}} = 480 \text{ seconds}$$

(b) What is unknown? Number of years
What is known? 253 days, 365 days/1 year

$$253 \text{ days} \times \frac{1 \text{ year}}{365 \text{ days}} = 0.693 \text{ years}$$

(c) What is unknown? Number of centuries
What is known? 9 decades, 10 decade/1 century

$$9 \text{ decades} \times \frac{1 \text{ century}}{10 \text{ decades}} = 0.9 \text{ centuries}$$

(d) What is unknown? Number of dozen apples
What is known? 5184 apples, 12 apples/1 dozen apples

$$5184 \text{ apples} \times \frac{1 \text{ dozen apples}}{12 \text{ apples}} = 432 \text{ dozen apples}$$

2.23 (a) What is unknown? Number of seconds
What is known? 5.00 minutes, 60 seconds/l minute

$$5.00 \text{ minutes} \times \frac{60 \text{ seconds}}{1 \text{ minute}} = 300 \text{ seconds}$$

(b) What is known? 0.850 minutes, 60 seconds/l minute

$$0.850 \text{ minutes} \times \frac{60 \text{ seconds}}{1 \text{ minute}} = 51.0 \text{ seconds}$$

(c) What is known? 1.25 hours, 60 minutes/1 hour, 60 seconds/1 minute

$$1.25 \text{ hours} \times \frac{60 \text{ minutes}}{1 \text{ hour}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} = 4{,}500 \text{ seconds}$$

(d) What is known? 3.1 days, 24 hours/1 day, 60 minutes/1 hour, 60 seconds/1 minute

$$3.1 \text{ days} \times \frac{24 \text{ hours}}{1 \text{ day}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} = 267{,}840 \text{ seconds}$$

2.24 (b) What is unknown? Number of hours
What in known? 25 years, 365 days/1 year

$$25 \text{ years} \times \frac{365 \text{ days}}{1 \text{ year}} \times \frac{24 \text{ hours}}{1 \text{ day}} = 219{,}000 \text{ hours}$$

(d) What is unknown? Number of seconds
What is known? 25 years, 365 days/1 year, 24 hours/1 day, 60 minutes/1 hour, 60 seconds/1 minute

$$25 \text{ years} \times \frac{365 \text{ days}}{1 \text{ year}} \times \frac{24 \text{ hours}}{1 \text{ day}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} \times \frac{60 \text{ seconds}}{1 \text{ minute}}$$
$$= 788{,}400{,}000 \text{ seconds}$$

(a) 9,125 days (c) 13,140,000 minutes

2.25 (a) What is unknown? Number of years
What is known? 9641 hours, 24 hours/1 day, 365 days/1 year

$$9641 \text{ hours} \times \frac{1 \text{ day}}{24 \text{ hours}} \times \frac{1 \text{ year}}{365 \text{ days}} = 1.101 \text{ years}$$

(b) What is unknown? Number of decades
What is known? 6505 days, 365 days/1 year, 10 years/1 decade

$$6505 \text{ days} \times \frac{1 \text{ year}}{365 \text{ days}} \times \frac{1 \text{ decade}}{10 \text{ years}} = 1.782 \text{ decades}$$

(d) What is unknown? Number of days
What is known? 915,000 seconds, 60 seconds/1 minute, 60 minutes/1 hour, 24 hours/1 day

$$915{,}000 \text{ seconds} \times \frac{1 \text{ minute}}{60 \text{ seconds}} \times \frac{1 \text{ hour}}{60 \text{ minutes}} \times \frac{1 \text{ day}}{24 \text{ hours}} = 10.6 \text{ days}$$

(c) 438,000 days (e) 0.274 millennia

2.27 (a) What is unknown? Number of drams/pound
What is known? 16 ounces/1 pound, 16 drams/1 ounce

$$\frac{16 \text{ ounces}}{1 \text{ pound}} \times \frac{16 \text{ drams}}{1 \text{ ounce}} = \frac{256 \text{ drams}}{\text{pound}}$$

(b) What is unknown? Number of grains/pound
What is known? 16 ounces/1 pound, 16 drams/1 ounce, 16 drams/437.5 grains

$$\frac{16 \text{ ounces}}{1 \text{ pound}} \times \frac{16 \text{ drams}}{1 \text{ ounce}} \times \frac{437.5 \text{ grains}}{16 \text{ drams}} = \frac{7{,}000 \text{ grains}}{\text{pound}}$$

(c) What is unknown? Number of drams/grain
What is known? 16 drams/437.5 grains

$$\frac{16 \text{ drams}}{437.5 \text{ grains}} = \frac{0.0366 \text{ drams}}{\text{grain}}$$

2.29 (a) What is unknown? cost, in $
What is known? 6 bananas, 9 bananas/2.9 lbs, $0.35/1 lb

$$6 \text{ bananas} \times \frac{2.9 \text{ lb}}{9 \text{ bananas}} \times \frac{\$0.35}{1 \text{ lb}} = \$0.68$$

(b) What is unknown? Number of dozens of bananas
What is known? $12.40, $0.35 cents/1 lb, 9 bananas/2.9 lb, 12 bananas/1 dozen

$$\$12.40 \times \frac{1 \text{ lb}}{\$0.35} \times \frac{9 \text{ bananas}}{2.9 \text{ lbs}} \times \frac{1 \text{ dozen}}{12 \text{ bananas}} = 9.16 \text{ dozen}$$

(c) What is unknown? cost, in cents
What is known? 1 banana, 9 bananas/2.9 lb, 35 cents/1 lb

$$1 \text{ banana} \times \frac{2.9 \text{ lb}}{9 \text{ bananas}} \times \frac{\$0.35}{1 \text{ lb}} = \$0.11$$

2.30 (a) What is unknown? Number of miles/gallon
What is known? 1317 miles, 49 gallons

$$1317 \text{ miles} \times \frac{1}{49 \text{ gallons}} = \frac{27 \text{ miles}}{\text{gallon}}$$

(d) What is unknown? Cost, in $
What is known? 49 gallons, $1.05/1 gallon

$$49 \text{ gallons} \times \frac{\$1.05}{1 \text{ gallon}} = \$51.45$$

(b) 0.037 gallons\mile (c) $3.91

2.31 (a) What is unknown? Coast in dollars
What is known? 34 paper clips, 0.79 dollars/100 paper clips

$$34 \text{ paper clips} \times \frac{\$0.79}{100 \text{ paper clips}} = \$0.27$$

(b) What is unknown? Cost, in $
What is known? 1 paper clip, $0.79 dollars/100 paper clips

$$1 \text{ paper clip} \times \frac{\$0.79}{100 \text{ paper clips}} = \$0.0079$$

(c) $6.08/pound (d) 62 boxes (e) 8.9 pounds

2.33 (a) What is unknown? Number of seconds
What is known? 75 years, 365 days/1 year, 24 hours/1 day, 60 minutes/1 hour, 60 seconds/1 minute

$$75 \text{ years} \times \frac{365 \text{ days}}{1 \text{ year}} \times \frac{24 \text{ hours}}{1 \text{ day}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} \times \frac{60 \text{ seconds}}{1 \text{ minute}}$$
$$= 2{,}365{,}200{,}000 \text{ seconds}$$

(b) What is unknown? Number of decades
What is known? 75 years, 10 years/1 decade

$$75 \text{ years} \times \frac{1 \text{ decade}}{10 \text{ years}} = 7.5 \text{ decades}$$

(c) What is unknown? Number of days
What is known? 75 years, 365 days/1 year

$$75 \text{ years} \times \frac{365 \text{ days}}{1 \text{ year}} = 27{,}375 \text{ days}$$

2.34 (a) What is unknown? Number of rods/furlong
What is known? 660 feet/1 furlong, 198 inches/1 rod, 12 inches/1 foot

$$\frac{660 \text{ feet}}{1 \text{ furlong}} \times \frac{12 \text{ inches}}{1 \text{ foot}} \times \frac{1 \text{ rod}}{198 \text{ inches}} = \frac{40 \text{ rods}}{\text{furlong}}$$

(c) What is unknown? Number of rods
What is known? 1 fathom, 6 feet/1 fathom, 660 feet/1 furlong, 198 inches/ 1 rod, 12 inches/1 foot

$$1 \text{ fathom} \times \frac{6 \text{ feet}}{1 \text{ fathom}} \times \frac{12 \text{ inches}}{1 \text{ feet}} \times \frac{1 \text{ rod}}{198 \text{ inches}} = 0.3636 \text{ rods}$$

(b) 50 furlongs (d) 0.22 yards

2.37 (a) What is unknown? Number of miles
What is known? 0.23 days, 24 hours/1 day, 60 minutes/1 hour, 60 seconds/1 minute, 186,000 miles/1 second

$$0.23 \text{ days} \times \frac{24 \text{ hours}}{1 \text{ day}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} \times \frac{186{,}000 \text{ miles}}{1 \text{ second}}$$
$$= 3{,}700{,}000{,}000 \text{ miles}$$

(b) What is unknown? Number of miles
What is known? 1 year, 365 days/1 year, 24 hours/1 day, 60 minutes/1 hour, 60 seconds/1 minute, 186,000 miles/1 second

$$1 \text{ year} \times \frac{365 \text{ days}}{1 \text{ year}} \times \frac{24 \text{ hours}}{1 \text{ day}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} \times \frac{186{,}000 \text{ miles}}{1 \text{ second}} = 5{,}900{,}000{,}000{,}000 \text{ miles}$$

This distance is called a light year.

2.39 (a) What is unknown? Number of acres
What is known? 571,000 miles^2, 43,560 ft^2/1 acre, 5,280 ft/1 mile so there are 5280^2 ft^2/1 mile^2

$$571{,}000 \text{ miles}^2 \times \frac{5280^2 \text{ ft}^2}{1 \text{ mile}^2} \times \frac{1 \text{ acre}}{43{,}560 \text{ ft}^2} = 365{,}000{,}000 \text{ acres}$$

(b) What is unknown? Number of ft^2
What is known? 571,000 miles^2, 5280^2 ft^2/1 mile^2

$$571{,}000 \text{ miles}^2 \times \frac{5280^2 \text{ ft}^2}{1 \text{ mile}^2} = 15{,}900{,}000{,}000{,}000 \text{ ft}^2$$

(c) What is unknown? Number of in^2
What is known? 571,000 miles, 5280 ft^2/1 mile^2, 12^2 in^2/1 ft^2

$$571{,}000 \text{ miles}^2 \times \frac{5{,}280^2 \text{ ft}^2}{1 \text{ mile}^2} \times \frac{12^2 \text{ in}^2}{1 \text{ ft}^2} = 2{,}290{,}000{,}000{,}000{,}000 \text{ in}^2$$

CHAPTER THREE

CHEMICAL MEASUREMENT

3.31 (a) A centigram balance measures to 0.1 g; an analytical balance measures to 0.0001 g. The analytical balance is more precise.
(c) A large graduated cylinder such as 500 mL measures to 1 mL; a small graduated cylinder such as 10 mL measures 0.01 mL. The small graduated cylinder is more precise.
(b) Pipet, ± 0.01 mL (d) Volumetric flask, ± 0.01 mL

3.34 (a) 5, All are significant.
(b) 7, All are significant.
(c) 2, The two zeros are placeholders and are not significant.
(g) 6, The three leading zeros are placeholders and are not significant.
(i) 1, Only the 5 is significant. 10^{-8} represents a placeholder and is not significant.
(d) 5 (e) 4 (f) 6 (h) 1 (i) 3

3.35 The least significant figure is always the smallest place (furthest to the right). Only zeros that are placeholders are nonsignificant.
(a) 4 (b) last 0 (c) 8 (d) last 0 (e) last 0 (f) last 0 (g) last 0
(h) 2 (i) 0 (j) 5

3.36 (d) 0.001 (e) 5×10^{2} (f) 0.000000002 (h) 0.002 (l) 9×10^{1}

3.37 (a) 194.6 - 4 < 5 so retain the 6
(c) 962.2 - Since the 5 is followed by a 3, add 1 to the least significant figure making it a 2.
(e) 9.997×10^{11} - Since the 5 is followed by 0004, add 1 to the least significant figure making in a 7. The exponent of 10 is required to show the correct placement of the decimal.
(b) 11.00 (d) 0.6591

3.38 (a) 9×10^{4} (b) 9.0×10^{4} (d) 9.000×10^{4}

3.39 (a) 4.8 g - The least significant figure is the tenths place in 2.5.
(b) 43.87 mL - The least significant figure is in the hundredths place in 11.87
(d) 756.87 m - The least significant figure is in the hundredths place in 91.15.
(c) 18.187 g

3.40 (a) 97.3 mL - The least significant figure is in the tenths place in 56.9.

3.40 (c) 0.034 g - The least significant figure is in the thousandths place in both numbers.
(b) 0.168 cm (d) 69.2 mm

3.41 (b) 5.9×10^3 s^2 - The least number of significant figures is two in 8.1. Scientific notation is necessary to correctly place the decimal.
(c) 54 cm^2 - The smallest number of significant figures is two in 9.9.
(a) 0.5 g^2 (d) 4.470 kg^2

3.42 (a) 6.6 g/mL - The least number of significant figures is two in 1.4.
(c) 1×10^{20} m/s - The least number of significant figures is one in 4×10^{-6}.
(b) 174.8 (d) 7.6×10^{-4} g/cm^3

3.43 (a) $133 \times 534.00 = 7.10 \times 10^4$, $9.1 + 0.4543 = 9.6$
$7.10 \times 10^4 / 9.6 = 7.4 \times 10^4$
(b) 0.286, 154.7325 – 154.7036 = 0.0289 which contains three significant figures.
(c) 0.00702

3.48 (b) $1669 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} = 16.69 \text{ m}$

(c) $4.3 \text{ km} \times \frac{1000 \text{ m}}{1 \text{km}} \times \frac{100 \text{ cm}}{1 \text{ m}} = 4.3 \times 10^5 \text{ cm}$

(f) $74.6 \text{ Mm} \times \frac{1{,}000{,}000 \text{ m}}{1 \text{Mm}} \times \frac{1 \text{ km}}{1000 \text{ m}} = 7.46 \times 10^4 \text{ km}$

(a) 9.1×10^4 mm (d) 6.8×10^9 μm (e) 3.580×10^8 nm

3.49 (a) $1 \text{ mi} \times \frac{1.609 \text{ km}}{1 \text{ mi}} \times \frac{1000 \text{ m}}{1 \text{ km}} = 2 \times 10^3 \text{ m}$

(b) $23 \text{ mi} \times \frac{5280 \text{ ft}}{1 \text{ mi}} \times \frac{12 \text{ in}}{1 \text{ ft}} = 1.5 \times 10^6 \text{ in}$

(d) $56 \text{ mi} \times \frac{1.609 \text{ km}}{1 \text{ mi}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1000 \text{ mm}}{1 \text{ m}} = 9.0 \times 10^7 \text{ mm}$

(f) $486.0 \text{ mi} \times \frac{1.609 \text{ km}}{1 \text{ mi}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ Mm}}{1{,}000{,}000 \text{ m}} = 0.7820 \text{ Mm}$

(c) 9.8×10^5 cm (e) 1.13×10^3 km

3.50 (a) $19 \text{ in} \times \frac{1 \text{ ft}}{12 \text{ in}} \times \frac{1 \text{ mi}}{5280 \text{ ft}} \times \frac{1.609 \text{ km}}{1 \text{ mi}} = 0.00048 \text{ km}$

(b) $36.9 \text{ ft} \times \frac{1 \text{ yd}}{3 \text{ ft}} \times \frac{0.9144 \text{ m}}{1 \text{ yd}} \times \frac{1000 \text{ mm}}{1 \text{ m}} = 1.12 \times 10^4 \text{ mm}$

3.50 (c) 5 ft 10 in = 70 in

$$70 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} \times \frac{1 \text{ m}}{100 \text{ cm}} = 1.8 \text{ m}$$

(d) 124.4 m (e) 3.8×10^4 nm (f) 5.6566×10^7 mm

3.53

$$130 \text{ lb} \times \frac{0.454 \text{ kg}}{1 \text{ lb}} = 59 \text{ kg}$$

$$5'7'' = 67'', 67 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = 170 \text{ cm}$$

$$37 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = 94 \text{ cm}$$

$$30 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = 76 \text{cm}$$

$$35 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = 89 \text{ cm}$$

3.55 (b) $74 \text{ mg} \times \frac{1 \text{ g}}{1000 \text{ mg}} = 0.074 \text{ g}$

(c) $9.7115 \times 10^{12} \mu\text{g} \times \frac{1 \text{ g}}{1 \times 10^6 \mu\text{g}} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 9711.5 \text{ kg}$

(f) $45.2 \times 10^{19} \text{ mg} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ Mg}}{1 \times 10^6 \text{ g}} = 4.52 \times 10^{11} \text{ Mg}$

(h) $8.395 \times 10^8 \text{ g} \times \frac{100 \text{ cg}}{1 \text{ g}} = 8.395 \times 10^{10} \text{ cg}$

(a) 5.873×10^7 mg (d) 1.293×10^{16} pg (e) 4.38×10^3 μg (g) 0.22 dg

3.56 (b) $6186 \text{ oz} \times \frac{1 \text{ lb}}{16 \text{ oz}} \times \frac{453.6 \text{ g}}{1 \text{ lb}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 1.754 \times 10^8 \text{ mg}$

(d) $12.033 \text{ lb} \times \frac{453.59 \text{ g}}{1 \text{ lb}} \times \frac{100 \text{ cg}}{1 \text{ g}} = 5.4581 \times 10^5 \text{ cg}$

(e) $8.43 \times 10^{-3} \text{ lb} \times \frac{454 \text{ g}}{1 \text{ lb}} \times \frac{1 \times 10^9 \text{ ng}}{1 \text{ g}} = 3.83 \times 10^9 \text{ ng}$

(a) 2.4×10^4 g (c) 0.9879 Mg (f) 1.12×10^{16} dg

3.57 (a) K = °C + 273.15 = 11 + 273.15 = 284 K

(c) K = °C + 273.15 = –235.6 + 273.15 = 37.6 K

(b) 212 K (d) 275.19 K

3.58 (a) °C = K – 273.15 = 88 – 273.15 = -1.9×10^2°C

(d) °C = K –273.15 = 3221 – 273.15 = 2948°C

(b) 41.6°C (c) –272.76°C

3.59 (b) $°C = 5/9(°F - 32) = 5/9(-77.7 - 32) = -60.94°C$

(c) $°C = 5/9(°F - 32) = 5/9(1466 - 32) = 796.7°C$

(a) 25.4°C (d) –273°C

3.60 (a) $°F = 9/5°C + 32 = 9/5(77.7) + 32 = 172°F$

(d) $°F = 9/5°C + 32 = 9/5(-140.0) + 32 = -220.0°F$

(b) –108°F (c) 2671°F

3.61 (c) $°C = K - 273.15 = 1111.11 - 273.15 = 837.96°C$

$°F = 9/5°C + 32 = 9/5(837.96) + 32 = 1540.3°F$

(d) $°C = K - 273.15 = 0.89 - 273.15 = -272.26°C$

$°F = 9/5°C + 32 = 9/5(-272.26) + 32 = -458.07°F$

(a) –195.4°C = –319.8°F (b) –174.6°C = –282.2°F

3.62 We are asked to find the temperature at which °C = °F.

$°C = °F = x$

$°C = 5/9(°F - 32)$

$x = 5/9(x - 32)$

$x = 5x/9 - 17.8$

$4x/9 = -17.8$

$x = -40.0$

3.65 (a) $934 \text{ mm} \times \frac{1 \text{ m}}{1000 \text{ mm}} \times \frac{100 \text{ cm}}{1 \text{ m}} = 93.4 \text{ cm}$

$2.1 \text{ cm} \times 0.54 \text{ cm} \times 93.4 \text{ cm} = 1.1 \times 10^2 \text{ cm}^3$

(b) $1.1 \times 10^2 \text{ cm}^3 \times \frac{1 \text{ m}^3}{1003 \text{ cm}^3} \times \frac{10^3 \text{ dm}^3}{1 \text{ m}^3} = 0.11 \text{ dm}^3$

(c) 1.1×10^2 mL (d) 0.11 L

3.67 (b) $12 \text{ mL} \times \frac{1 \text{ cm}^3}{1 \text{ mL}} \times \frac{1 \text{ m}^3}{100 \text{ cm}^3} = 1.2 \times 10^{-5} \text{ m}^3$

(c) $73.570 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1 \times 10^6 \ \mu\text{L}}{1 \text{ L}} = 73570 \ \mu\text{L}$

(f) $1.2 \times 10^7 \ \mu\text{L} \times \frac{1 \text{ L}}{1 \times 10^6 \ \mu\text{L}} \times \frac{1 \times 10^{-3} \text{ m}^3}{1 \text{ L}} = 0.012 \text{ m}^3$

(a) $3.98 \times 10^3 \text{ cm}^3$ (d) 1.14×10^6 mL (e) 0.5082 m^3

3.69 (a) $177 \text{ gal} \times \frac{4 \text{ qt}}{1 \text{ gal}} \times \frac{0.946 \text{ L}}{1 \text{ qt}} \times \frac{1 \times 10^{-3} \text{ m}^3}{1 \text{ L}} = 0.670 \text{ m}^3$

3.69 (b) $50.45\ \text{pt} \times \frac{1\ \text{qt}}{2\ \text{pt}} \times \frac{0.9463\ \text{L}}{1\ \text{qt}} \times \frac{1000\ \text{cm}^3}{1\ \text{L}} = 2.386 \times 10^4\ \text{cm}^3$

(c) $2.88 \times 10^{-5}\ \text{dm}^3$ (d) $4.2 \times 10^3\ \text{mm}^3$

3.70 (a) 651 g/49.9 mL = 13.0 g/mL

(c) $1.58\ \text{kg} \times \frac{1}{1.677\ \text{L}} \times \frac{1\ \text{L}}{1000\ \text{mL}} \times \frac{1000\ \text{g}}{1\ \text{kg}} = 0.942\ \text{g/mL}$

(b) 0.860 g/mL (d) 3.72 g/mL

3.71 (b) $544\ \text{mL} \times \frac{6.11\ \text{g}}{1\ \text{mL}} = 3.32 \times 10^3\ \text{g}$

(e) $1\ \text{qt} \times \frac{0.946\ \text{L}}{1\ \text{qt}} \times \frac{1000\ \text{mL}}{1\ \text{L}} \times \frac{6.11\ \text{g}}{1\ \text{mL}} = 6 \times 10^3\ \text{g}$

(f) $0.000671\ \text{m}^3 \times \frac{1\ \text{L}}{1 \times 10^{-3}\ \text{m}^3} \times \frac{1000\ \text{mL}}{1\ \text{L}} \times \frac{6.11\ \text{g}}{1\ \text{mL}} = 4.10 \times 10^3\ \text{g}$

(a) $2.0 \times 10^2\ \text{g}$ (c) $1.29 \times 10^6\ \text{g}$ (d) 1.77 g

3.72 (a) $834.6\ \text{g} \times \frac{1\ \text{mL}}{2.33\ \text{g}} = 358\ \text{mL}$

(c) $3.330\ \text{kg} \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mL}}{2.33\ \text{g}} = 1.43 \times 10^3\ \text{mL}$

(d) $71.9\ \text{lb} \times \frac{454\ \text{g}}{1\ \text{lb}} \times \frac{1\ \text{mL}}{2.33\ \text{g}} = 1.40 \times 10^4\ \text{mL}$

(b) 0.386 mL (e) $3.86 \times 10^6\ \text{mL}$

3.73 (b) $\frac{1.29\ \text{g}}{1\ \text{L}} \times \frac{1\ \text{L}}{1 \times 10^{-3}\ \text{m}^3} \times \frac{1\ \text{kg}}{1000\ \text{g}} = 1.29\ \text{kg/m}^3$

(c) $\frac{1.29\ \text{g}}{1\ \text{L}} \times \frac{1\ \text{L}}{1000\ \text{mL}} \times \frac{1\ \text{mL}}{1\ \text{cm}^3} \times \frac{2.543\ \text{cm}^3}{1\ \text{in}^3} \times \frac{123\ \text{in}^3}{1\ \text{ft}^3} \times \frac{1\ \text{lb}}{454\ \text{g}} = \frac{0.0805\ \text{lb}}{\text{ft}^3}$

(a) $36.5\ \text{g/ft}^3$ (d) $0.00129\ \text{mg/mm}^3$ (e) $1.29 \times 10^{-6}\ \text{kg/cm}^3$

3.75 Mass of liquid = 69.7 g – 40.1 g = 29.6 g
29.6 g/18.6 mL = 1.59 g/mL

3.77 Mass of liquid = 69.731 g – 45.045 g = 24.676 g
24.676 g/15.0 mL = 1.65 g/mL

3.78 The density of air is $1.29\ \text{g/dm}^3$ (from Table 3.2)

$6.1\ \text{m} \times 5.5\ \text{m} \times 4.3\ \text{m} = 1.4 \times 10^2\ \text{m}^3$

$1.4 \times 10^2\ \text{m}^3 \times \frac{1 \times 10^3\ \text{dm}^3}{1\ \text{m}^3} \times \frac{1.29\ \text{g}}{1\ \text{dm}^3} = 1.8 \times 10^5\ \text{g}$

3.80 (a) $\frac{0.0147\ g}{0.187\ g^2} = \frac{0.0786}{g}$

(b) $73.25\ m^2 - 67.9\ m^2 + \frac{5.93 \times 10^3\ m^{-g^2}}{81.04\ m} = 5.3\ m^2 + 73.2\ m^2 = 78.6\ m^2$

(c) $0.00345\ m^3 \times \frac{100^3\ cm^3}{1\ m^3} = 3.45 \times 10^3\ cm^3$

$1.37 + \frac{1025.0\ cm^3}{3.45 \times 10^3\ cm^3} = 1.37 \times 0.297 = 0.408$

3.81 (a) $9.32\ mg \times \frac{1\ g}{1000\ mg} \times \frac{1\ Mg}{1 \times 10^6\ g} = 9.32 \times 10^{-9}\ Mg$

(b) $0.02445\ cm^3 \times \frac{1\ m^3}{100^3\ cm^3} = 2.445 \times 10^{-8}\ m^3$

(c) $3.22\ cm \times \frac{1\ m}{100\ cm} \times \frac{1 \times 10^{12}\ pm}{1\ m} = 3.22 \times 10^{10}\ pm$

(d) $°F = 9/5°C + 32 = (9/5)(81.4) + 32 = 179°F$

(e) $9561\ g \times \frac{100\ cg}{1\ g} = 9.561 \times 10^5\ cg$

(f) $\frac{1\ L}{1\ dm^3} \times \frac{1000\ mL}{1\ L} \times \frac{1.63\ g}{1\ mL} \times \frac{1\ kg}{1000\ g} = \frac{1.63\ kg}{dm^3}$

(g) $K = 273.15 + °C = 273.15 + (-248) = 25\ K$

(h) $451\ nL \times \frac{1 \times 10^{-9}\ L}{1\ nL} \times \frac{1 \times 10^{-3}\ m^3}{1\ L} = 4.51 \times 10^{-10}\ m^3$

3.83 (a) $1\ gill \times \frac{7.219\ in^3}{1\ gill} \times \frac{2.54^3\ cm^3}{1\ in^3} = 118.3\ cm^3$

(b) $25\ gills \times \frac{7.219\ in^3}{1\ gill} \times \frac{2.54^3\ cm^3}{1\ in^3} \times \frac{1\ m^3}{100^3\ cm^3} \times \frac{5.897\ kg}{1\ m^3} \times \frac{1000\ g}{1\ kg} = 17\ g$

3.86 (a) $\frac{555\ mi}{1\ hr} \times \frac{1.609\ km}{1\ mi} = \frac{893\ km}{hr}$

(b) $\frac{1\ min}{60\ s} \times \frac{1\ hr}{60 min} \times \frac{555\ mi}{1\ hr} \times \frac{1.609\ km}{1\ mi} \times \frac{1000\ m}{1\ km} = \frac{248\ m}{s}$

(c) $\frac{1 \times 10^{-9}\ s}{1\ ns} \times \frac{1\ min}{60 s} \times \frac{1\ hr}{60\ min} \times \frac{555\ mi}{1\ hr} \times \frac{1.609\ km}{1\ mi} \times \frac{1000\ m}{1\ km}$

$\times \frac{1000\ mm}{1\ m} = \frac{0.000248\ mm}{ns}$

3.87 $V = \pi\ (1.88\ cm/2)^2 \times (3.22\ cm) = 8.94\ cm^3$

$\frac{124.54\ g}{8.94\ cm^3} = \frac{13.9\ g}{cm^3}$

3.90 (a) $2.0\ \text{L} \times \frac{1000\ \text{cm}^3}{1\ \text{L}} \times \frac{1\ \text{in}^3}{2.54^3\ \text{cm}^3} = 1.2 \times 10^2\ \text{in}^3$

(b) $2.0\ \text{L} \times \frac{1 \times 10^{-3}\ \text{m}^3}{1\ \text{L}} = 0.0020\ \text{m}^3$

3.94 $$\frac{1.33\ \text{kg}}{1} \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{cm}^3}{2.39\ \text{g}} \times \frac{1\ \text{m}^3}{100^3\ \text{cm}^3} \times \frac{(1 \times 10^6)^3\ \mu\text{m}^3}{1\ \text{m}^3} \times \frac{1\ \text{particle}}{8.22\ \mu\text{m}^3}$$
$$= 6.77 \times 10^{13}\ \text{particles}$$

3.95 Calculate the volume at 20°C.

$1.000\ \text{g} \times \frac{1\ \text{cm}^3}{13.546\ \text{g}} = 0.07382\ \text{cm}^3$

Calculate the volume at 30°C.

$1.000\ \text{g} \times \frac{1\ \text{cm}^3}{13.521\ \text{g}} = 0.07396\ \text{cm}^3$

The change in volume is:

$0.07396\ \text{cm}^3 - 0.07382\ \text{cm}^3 = 0.00014\ \text{cm}^3$

CHAPTER FOUR

MATTER AND ENERGY

4.34 A physical property is a characteristic of a substance that can be determined without changing the composition of the substance. A chemical property describes how the composition of a substance changes or does not change when it interacts with other substances or energy forms.
Physical: (a), (b), (f), (h), (i), (k), (l), (m)
Chemical: (c), (d), (e), (g), (j), (n), (o)

4.35 A physical change occurs when the physical properties of a substance are altered, but the composition remains the same. A chemical change occurs when the composition of a substance changes – a new substance is formed.
Physical: (a), (d), (e), (f), (i), (k)
Chemical: (b), (c), (g), (h), (j)

4.37 Yellow color, solid state, melting point, and boiling point are properties that are determined without any change in composition, so they are physical properties. Burns in air results in a change in composition, so it is a chemical property.

4.40 Viscosity is a measure of the resistance to flow. A substance that does not flow readily has a high viscosity.
(a) Vegetable oil does not flow as readily as water, so it has a higher viscosity.
(d) Molasses does not flow as readily as shaving cream, so it has a higher viscosity.
(b) Motor oil (c) Pudding

4.41 (c) Liquid (e) Liquid (f) Solid (g) Solid (h) Solid

4.44 (d) Pure substance (e) Element

4.45 A pure substance has the same composition throughout, cannot be separated into its components by a physical method, and its changes of state occur at a constant temperature. A mixture is composed of two or more substances that are physically associated. The composition of a mixture is variable, its components may be separated by physical methods, and the changes of state occur over a range of temperatures.

4.45 (a) Wine is a mixture composed of many compounds.
(e) Charcoal is a mixture of an element and compounds.
(g) A sugar cube is a pure substance (sugar is a compound).
(h) Paint is a mixture of several compounds.
(k) Cola drinks are mixtures of several compounds.
Pure substances: (c), (f), (i)
Mixtures: (b), (d), (j)

4.55 (b) Sulfur 1, oxygen 3 (c) Nitrogen 2, oxygen 5 (e) Sodium 1, nitrogen 1, oxygen 3 (h) Nitrogen 2, hydrogen 8, carbon 2, oxygen 4 (j) Carbon 1, chlorine 2, bromine 2

4.56 (b) Since P_2O_5 contains only phosphorus and oxygen, the element phosphorus could combine with oxygen to form P_20_5.
(a) Compound (c) Element

4.58 A heterogeneous mixture exhibits more than one phase. A homogeneous mixture is composed of only one phase.
(a) Brass is a homogeneous mixture composed of one solid phase.
(c) Cement is a heterogeneous mixture of solid phases.
(d) Motor oil is a homogeneous mixture of liquid phases.
(e) Cotton is a homogeneous mixture of solid phases.
(g) Oil and vinegar is a heterogeneous mixture of liquid phases.
Homogeneous: (b), (f)
Heterogeneous: (h)

4.59 (a) Dissolve the salt in water and filter to separate the sand, then boil off the water to recover the salt.
(c) Dissolve the sugar in water and filter to separate the sand, then carefully evaporate the water by heating to recover the sugar.
(d) Pour off the oil, leaving the water.

4.60 (a) Ice (solid) and tea (liquid) make two phases.
(b) Seawater (liquid) and oil (liquid) give two phases.
(c) Sand (solid) and water (liquid) give two phases.
(d) Soda water contains the gas carbon dioxide and liquid water, two phases. Ice, a solid, is the third phase.

4.63 (a) $[5.23\ \text{kg} \times (2.25\ \text{m/s})^2]/2 = 13.2\ \text{kg.m}^2/\text{s}^2 = 13.2\ \text{J}$
(b) 3.34 J (c) 65.4 J

4.65 (b) Position and composition (c) Condition (f) Composition

4.66 (a) The larger Bunsen burner flame will transfer more heat.
(e) Identical objects at the same temperature are able to transfer the same amount of heat.
(b) Bath tub (c) Ice cube (d) Gallon of water

4.67 (a) $9.21 \text{ cal} \times \frac{4.184 \text{ J}}{1 \text{ cal}} = 38.5 \text{ J}$

(d) $8.1 \times 10^7 \text{ cal} \times \frac{4.184 \text{ J}}{1 \text{ cal}} \times \frac{1 \text{ kJ}}{1000 \text{ J}} = 3.4 \times 10^5 \text{ kJ}$

(b) 1.69 cal (c) 5.182 kcal (e) 2.24×10^{-5} kJ

4.69 The unknown is specific heat which has the units J/g·°C.
$\Delta T = 15.9°C - 8.32°C = 7.6°C$

$$521 \text{ J} \times \frac{1}{217 \text{ g}} \times \frac{1}{7.6°C} = \frac{0.32 \text{ J}}{\text{g}\cdot°C}$$

4.70 The specific heat of water is 4.184 J/g·°C.
$\Delta T = 54.1°C - 29.8°C = 24.3°C$

$$8.43 \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{24.3°C}{} \times \frac{4.184 \text{ J}}{1 \text{ g}\cdot°C} = 8.57 \times 10^5 \text{ J}$$

4.73 The specific heat of water is 4.184 J/g·°C.
For 1.00 kg of water:
$\Delta T = 100.0°C - 25.0°C = 75.0°C$

$$1.00 \text{ kg} \times 75.0°C \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{4.184 \text{ J}}{1 \text{ g}\cdot°C} = 3.14 \times 10^5 \text{ J}$$

For 1.00 g of water:

$$1.00 \text{ g} \times 75.0°C \times \frac{4.184 \text{ J}}{1 \text{ g}\cdot°C} = 314 \text{ J}$$

4.75 The specific heat of copper (see Table 4.8) is 0.38 J/g·°C.

$$9.21 \times 10^3 \text{ J} \times \frac{1}{29.3 \text{ g}} \times \frac{1 \text{ g}\cdot°C}{0.38 \text{ J}} = 8.3 \times 10^2°C$$

This is the change in temperature, ΔT, not the final temperature.
The final temperature is $15.4°C + 8.3 \times 10^2°C = 8.4 \times 10^2°C$.

4.79 (b) $\Delta E = \Delta mc^2$

$$5.5 \times 10^{35} \text{ J} = \Delta m(3.00 \times 10^8 \text{ m/s})^2 = (9.00 \times 10^{16} \text{ m}^2/\text{s}^2)\Delta m$$

$$\Delta m = 6.1 \times 10^{18} \text{ kg}$$

$$6.1 \times 10^{18} \text{ kg} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 6.1 \times 10^{24} \text{ mg}$$

(a) 0.067 mg (c) 1.1×10^{-11} mg

4.80 (a) $\Delta E = \Delta mc^2 = (1.5 \times 10^{-6}\ \text{kg})(3.00 \times 10^8\ \text{m/s})^2 = 1.4 \times 10^{11}\ \text{J}$
(b) $1.16 \times 10^{12}\ \text{J}$ (c) $1.35 \times 10^{20}\ \text{J}$

4.81 $E_{kinetci} = \frac{1}{2}mv^2$
$5.78 \times 10^4\ \text{J} = (0.985\ \text{kg}/2)v^2$
$v^2 = 1.17 \times 10^5\ \text{J/kg}$
$v = 343\ \text{m/s}$

4.86 First calculate the heat absorbed by 123.8 g of water when the temperature rises from 23.19°C to 26.88°C, $\Delta T_{water} = 26.88°\text{C} - 23.19°\text{C} = 3.69°\text{C}$. The specific heat of the water is 4.184 J/g°C.

$$123.8\ \text{g} \times 3.69\,\cancel{°\text{C}} \times \frac{4.184\ \text{J}}{1\ \text{g}\cdot\cancel{°\text{C}}} = 1.91 \times 10^3\ \text{J}$$

The amount of heat released by the 30.0 g alloy is $-1.91 \times \times 10^3$ J when it cooled from 100.0°C to 26.88°C, $\Delta T_{alloy} = 26.88°\text{C} - 100.0°\text{C} = -73.1°\text{C}$. (The alloy and water must be at the same final temperature since they are in the same container.) Now calculate the specific heat of the alloy in J/g°C.

$$\frac{-1.91 \times 10^3\ \text{J}}{1} \times \frac{1}{30.0\ \text{g}} \times \frac{1}{-73.1°\text{C}} = 0.871\ \text{J/g}\cdot°\text{C}$$

4.88 (b) The specific heat of mercury (see Table 4.8) is 0.138 J/g°C.

$$9.22\ \cancel{\text{kg}} \times \frac{1000\ \text{g}}{1\ \cancel{\text{kg}}} \times \frac{0.138\ \text{J}}{1\ \text{g}\ °\text{C}} = \frac{1.27 \times 10^3\ \text{J}}{°\text{C}}$$

(a) $1.88 \times 10^3\ \text{J/°C}$ (c) 2.57 J/°C

4.89 The volume of the cube of Pt is:
$(3.28\ \text{cm})^3 = 35.3\ \text{cm}^3$
$\Delta T = 65.8°\text{C} - 11.7°\text{C} = 54.1°\text{C}$

$$54.1\,\cancel{°\text{C}} \times 35.5\ \cancel{\text{cm}^3} \times \frac{21.45\ \text{g}}{1\ \cancel{\text{cm}^3}} \times \frac{0.133\ \text{J}}{1\ \text{g}\ \cancel{°\text{C}}} = 5.45 \times 10^3\ \text{J}$$

4.91 The specific heat (see Table 4.8) of Ag and Cu is 0.23 J/g°C and 0.38 J/g°C respectively.
$\Delta T = 100.0°\text{C} - 24.9°\text{C} = 75.1°\text{C}$
The mass of silver in 0.438 kg of sterling silver is:

$$0.438\ \cancel{\text{kg sterling}} \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{92.5\ \text{g silver}}{100\ \cancel{\text{g sterling}}} = 405\ \text{g silver}$$

The heat required to raise the temperature of 405 g Ag from 24.9°C to 100.0°C is:

$$405\ \text{g} \times 75.1\,\cancel{°\text{C}} \times \frac{0.23\ \text{J}}{1\ \text{g}\ \cancel{°\text{C}}} = 7.00 \times 10^3\ \text{J}$$

4.91 The mass of copper in 0.438 kg of sterling silver is:

$$0.438 \cancel{\text{kg sterling}} \times \frac{1000 \text{ g}}{1 \cancel{\text{kg}}} \times \frac{7.5 \text{ g copper}}{100 \cancel{\text{g sterling}}} = 32.8 \text{ g copper}$$

The heat required to raise the temperature of 32.8 g Cu from 24.9°C to 100.0°C is:

$$32.8 \cancel{\text{g}} \times 75.1 \cancel{^\circ\text{C}} \times \frac{0.38 \text{ J}}{1 \cancel{\text{g}} \cdot \cancel{^\circ\text{C}}} = 9.4 \times 10^2 \text{ J}$$

The heat require is $7.00 \times 10^3 \text{ J} + 9.4 \times 10^2 \text{ J} = 7.9 \times 10^3 \text{ J}$

4.92 (a) The temperature changes are:

$\Delta T_{water} = 29.1^\circ\text{C} - 24.3^\circ\text{C} = 4.8^\circ\text{C}$

$\Delta T_{metal} = 29.1^\circ\text{C} - 121.4^\circ\text{C} = -92.3^\circ\text{C}$

The heat transferred to the water is:

$$q_{water} = 188.6 \cancel{\text{g}} \times 4.8 \cancel{^\circ\text{C}} \times \frac{4.184 \text{ J}}{\cancel{\text{g}} \cdot \cancel{^\circ\text{C}}} = 3.8 \times 10^3 \text{ J}$$

The specific heat of the metal is:

$$c_{metal} = \frac{1}{92.777 \text{ g}} \times \frac{1}{-92.3^\circ\text{C}} \times \frac{-3.8 \times 10^3 \text{ J}}{1} = \frac{0.44 \text{ J}}{\text{g} \cdot ^\circ\text{C}}$$

(b) $3.8 \times 10^3 \cancel{\text{J}} \times \frac{1 \text{ kJ}}{1000 \cancel{\text{J}}} = 3.8 \text{ kJ}$

4.93 (a) The temperature changes are:

$\Delta T_{water} = 26.6^\circ\text{C} - 23.6^\circ\text{C} = 3.0^\circ\text{C}$

$\Delta T_{metal} = 26.6^\circ\text{C} - 97.2^\circ\text{C} = -70.6^\circ\text{C}$

The heat transferred to the water is:

$$q_{water} = 115.0 \cancel{\text{g}} \times 3.0 \cancel{^\circ\text{C}} \times \frac{4.184 \text{ J}}{\cancel{\text{g}} \cdot \cancel{^\circ\text{C}}} = 1.4 \times 10^3 \text{ J}$$

The specific heat of the metal is:

$$c_{metal} = \frac{1}{55.00 \text{ g}} \times \frac{1}{-70.6^\circ\text{C}} \times \frac{-1.4 \times 10^3 \text{ J}}{1} = \frac{0.37 \text{ J}}{\text{g} \cdot ^\circ\text{C}}$$

(b) $1.4 \times 10^3 \cancel{\text{J}} \times \frac{1 \text{ kJ}}{1000 \cancel{\text{J}}} = 1.4 \text{ kJ}$

CHAPTER FIVE

ATOMS

5.31 (a) The atomic mass of any element may be used. As an example use copper:
1 atom Cu = 63.55 u, 1 mol Cu = 63.55 g

$$\frac{1\ \text{mol Cu}}{63.55\ \text{g}} \times \frac{6.022 \times 10^{23}\ \text{atoms Cu}}{1\ \text{mol Cu}} \times \frac{63.55\ \text{u}}{1\ \text{atom Cu}} = \frac{6.022 \times 10^{23}\ \text{u}}{\text{g}}$$

(b) $1\ p^+ = 1.007\ u$

$$\frac{1.007\ u}{1\ p^+} \times \frac{1\ g}{6.022 \times 10^{23} u} = \frac{1.673 \times 10^{-24}\ g}{p^+}$$

5.33 (a) $Z = 1 = \text{No. } p^+ = \text{No. } e^-$
$A = 3 = \text{No. } p^+ + \text{No. } n^\circ$
$3 = 1 + \text{No. } n^\circ$
$\text{No. } n^\circ = 3 - 1 = 2$

(e) $Z = 18 = \text{No. } p^+ = \text{No. } e^-$
$A = 40 = \text{No. } p^+ + \text{No. } n^\circ$
$40 = 18 + \text{No. } n^\circ$
$\text{No. } n^\circ = 40 - 18 = 22$

(h) $Z = 35 = \text{No. } p^+ = \text{No. } e^-$
$A = 81 = \text{No. } p^+ + \text{No. } n^\circ$
$81 = 35 + \text{No. } n^\circ$
$\text{No. } n^\circ = 81 - 35 = 46$

(i) $Z = 78 = \text{No. } p^+ = \text{No. } e^-$
$A = 195 = \text{No. } p^+ + \text{No. } n^\circ$
$195 = 78 + \text{No. } n^\circ$
$\text{No. } n^\circ = 195 - 78 = 117$

Symbol	Atomic Number	Mass Number	Number of Protons	Number of Neutrons	Number of Electrons
(b) $^{18}_{8}O$	8	18	8	10	8
(c) $^{23}_{11}Na$	11	23	11	12	11
(d) $^{31}_{15}P$	15	31	15	16	15
(f) $^{51}_{23}V$	23	51	23	28	23
(g) $^{59}_{27}Co$	27	59	27	32	27
(i) $^{108}_{46}Pd$	46	108	46	62	46

5.34 (a) $Z = 46 = \text{No. } p^+ = \text{No. } e^-$
$A = 108 = \text{No. } p^+ + \text{No. } n^\circ$
$108 = 46 + \text{No. } n^\circ$
$\text{No. } n^\circ = 108 - 46 = 62$
(c) $Z = 22 = \text{No. } p^+ = \text{No. } e^-$
$A = 48 = \text{No. } p^+ + \text{No. } n^\circ$
$48 = 22 + \text{No. } n^\circ$
$\text{No. } n^\circ = 48 - 22 = 26$
(b) 32 p^+, 38 n° (d) 85 p^+, 125 n°

5.35 (b) $\text{No. } p^+ = 53 = Z$
$A = \text{No. } p^+ + \text{No. } n^\circ = 53 + 74 = 127$
(a) $^{159}_{65}\text{Tb}$ (c) $^{102}_{44}\text{Ru}$

5.40 Average atomic mass of Eu = [(150.92 u)(47.82) + (152.92 u)(52.18)]/100
= 72.17 u + 79.79 u = 151.96 u

5.43 (a) Average atomic mass of Cu = $\frac{[(62.9298\text{ u})(69.09) + (64.9278\text{ u})(30.91)]}{100}$
43.48 u + 20.07 u = 63.55 u
(b) 72.63 u

5.52 (a) The maximum number of electrons that can be located in any orbital is 2.
(c) Be has an atomic number of 4, so it has 4 electrons.
(e) Any *f* sublevel is composed of seven *f* orbitals. Each orbital can hold 2 electrons, so a maximum of 14 electrons can occupy the *f* sublevel.
(g) Arsenic has the valence electron configuration $4s^24p^3$, so there are 3 electrons in the 4p subshell.
(i) The outermost electron in Br is in the 4p sublevel, so no electrons occupy the fifth energy level in the ground state of Br.
(b) 10 (d) 18 (f) 20 (h) 5 (i) 2 (k) 10

5.55 (a) $1s^22s^1$ (c) $1s^22s^22p^63s^1$ (d) $1s^22s^22p^63s^23p^1$
(g) $1s^22s^22p^63s^23p^64s^23d^{10}4p^6$ (h) $1s^22s^22p^63s^23p^64s^23d^1$
(l) $1s^22s^22p^63s^23p^64s^23d^{10}4p^2$

5.57 (a) Rb is the first element in the 5th period, so the outer electronic configuration is $5s^1$.
(c) Ga is the third representative in the 4th period, so the outer electronic configuration is $4s^24p^1$.
(f) Sn is the fourth representative element in the fifth period, so the outer electronic configuration is $5s^25p^2$.
(b) $4s^2$ (d) $4s^24p^4$ (e) $4s^24p^5$ (g) $5s^25p^3$ (h) $7s^2$ (i) $6s^26p^5$ (j) $7s^1$

5.58 (a) The total number of electrons is 7. Nitrogen is the element with the atomic number of 7.
(c) The total number of electrons is 15. Phosphorus is the element with the atomic umber of 15.
(g) The total number of electrons is 37. Rubidium is the element with the atomic number of 37.
(b) Mg (d) Ge (e) S (f) Br (h) Xe

5.61 (a) The group IIA element in the third period (3*s*) is Mg.
(c) The first atom with an electron in the 4*d* sublevel is yttrium, which has an atomic number of 39 (the 4*d* sublevel fills after the 5*s* sublevel). The remaining elements with atomic numbers between 39 and 43 are Zr, Nb, and Mo.
(f) The elements having only *s* electrons will have the electronic configurations $1s^1$, $1s^2$, $1s^22s^1$, and $1s^22s^2$. This corresponds to the H, He, Li, and Be. All of the remaining elements will contain *p* electrons.
(b) Se, Te, Po (d) Be, Mg, Ca, Sr, Ba (e) Kr

5.62 (a) Magnesium contains 12 electrons. If it loses 2 it will have 10 electrons and be isoelectronic to Ne. The electronic configuration of Ne is $1s^22s^22p^6$.
(c) Fluorine contains 9 electrons. If it gains 1 it will have 10 electrons and be isoelectronic to Ne.
(b) $1s^22s^22p^6$ (d) $1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^24d^{10}5p^6$

5.63 (a) $[Xe]6s^24f^{14}5d^{10}6p^2$
(b) $1s^22s^22p^63s^23p^63d^{10}4s^24p^64d^{10}5s^25p^6$

5.68 (a) $Z = 84 = \text{No. } p^+ = \text{No. } e^-$
$A = 208 = \text{No. } p^+ + \text{No. } n^\circ$
$208 = 84 + \text{No. } n^\circ$
$\text{No. } n^\circ = 208 - 84 = 124$
(c) $Z = 72 = \text{No. } p^+ = \text{No. } e^-$
$A = 180 = \text{No. } p^+ + \text{No. } n^\circ$
$180 = 72 + \text{No. } n^\circ$
$\text{No. } n^\circ = 180 - 72 = 108$
(b) 92 p^+, 143 n°, 92 e^- (d) 81 p^+, 124 n°, 81 e^-

5.69 Any symbol of an isotope with the same atomic number, but a different mass number is acceptable.
(a) $^{129}_{54}Xe$ $^{132}_{54}Xe$
(b) $^{15}_{8}O$ $^{18}_{8}O$
(c) $^{25}_{12}Mg$ $^{26}_{12}Mg$

5.69 (d) $^{138}_{57}La$ $^{137}_{57}La$

5.70 (a) Na has the outer electronic configuration $3s^1$. The excited state is obtained by promoting the electron to the next sublevel, which is the 3p. This results in the electronic configuration of $1s^2 2s^2 2p^6 3p^1$.

(b) $1s^2 2s^2 2p^5 3s^1$ (c) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^5 6s^1$

5.73 The diameter of an atom is about 100,000 times the diameter of the nucleus.

$$1 \text{ cm} \times 100{,}000 \times \frac{1 \text{ in}}{2.54 \text{ cm}} \times \frac{1 \text{ ft}}{12 \text{ in}} \times \frac{1 \text{ mile}}{5280 \text{ ft}} = 0.6 \text{ mile}$$

5.74 From Coulomb's law the force is inversely proportional to r^2. If the radius is tripled, r^2 increases by a factor of $3^2 = 9$. The force will be decreased by a factor of 9.

5.76 Let x = mass of $^{40}_{14}Si$. Now substitute into the formula for the average atomic mass.

$28.086 \text{ u} = [(27.9769 \text{ u})(92.21) + (28.9765 \text{ u})(4.70) + (x)(3.09)]/100$

Solve the equation for $x = 30.0$ u.

5.86 $$286 \text{ pm} \times \frac{1 \times 10^{-12} \text{ m}}{1 \text{ pm}} \times \frac{100 \text{ cm}}{1 \text{ m}} = 2.85 \times 10^{-8} \text{ cm}$$

$$V = (4/3)(3.14)(2.86 \times 10^{-8} \text{ cm}/2)^3 = 1.22 \times 10^{-23} \text{ cm}^3$$

CHAPTER SIX

PERIODIC PROPERTIES

6.21 (d) Nonmetal (e) Nonmetal (g) Metal (i) Metal (j) metal

6.22 (a) Low boiling point, low density, and a gas at room temperature are characteristics of a nonmetal.
(b) High boiling point, high density, and a conductor are characteristics of most metals.

6.23 Metallic character increases down a group, and decreases across the periodic table.
(a) Be is to the left of the other elements, so it is the most metallic.
(b) Sn is the furthermost down the group, so it is the most metallic.
(c) Sb, the one nearest the bottom left side on the periodic table, is the most metallic.
(d) Mg is the closest to the left side on the periodic table; hence, it is the most metallic.

6.24 (1) P, in group VA, has 5 outer-level electrons. It requires 3 more to give it 8 electrons in the outer energy level. This will give it a charge of 3–.
(3) F, in group VIIA, has 7 outer-level electrons. It requires 1 more electron to give it 8 in the outer energy level. This will give it a charge of 1–.
(4) Se, in group VIA, has 6 outer-level electrons. It requires 2 more to give it 8 in the outer energy level. This will give it a charge of 2–.
(a) (2) 1 (5) 3 (6) 1
(b) (2) 1– (5) 3– (6) 1–

6.25 (1) Cs, in group IA, has 1 outer-level electron. It will lose this electron to form an ion with a 1+ charge.
(2) Be, in group IIA, has 2 outer-level electrons. It will lose these 2 electrons to form an ion with a 2+ charge.
(3) Al, in group IIIA, has 3 outer-level electrons. It will lose these 3 electrons to form an ion with a 3+ charge.
(4) Sc, in group IIIB, has 3 outer-level electrons ($4s^2 3d^1$). It will lose these 3 electrons to form an ion with a 3+ charge.
(a) (5) 2 (6) 1
(b) (5) 2+ (6) 1+

6.26 (a) Sr, in group IIA, will lose 2 outer-level electrons and form an ion with a 2+ charge.

6.26 (b) P, in group VA, will gain 3 electrons and form an ion with a 3– charge.
(d) O, in group VIA, will gain 2 electrons and form an ion with a 2– charge.
(h) Rb, in group IA, will lose 1 outer-level electron and form an ion with a 1+ charge.
(i) F, in group VIIA, will gain 1 electron and form an ion with a 1- charge.
(c) 2– (e) 2+ (f) 2– (g) 3– (i) 2+

6.27 (a) $:\ddot{N}. + 3e^- \longrightarrow [:\ddot{N}:]^{3-}$

(b) $:\ddot{Cl}. + 1e^- \longrightarrow [:\ddot{Cl}:]^-$

(e) $:\ddot{P}. + 3e^- \longrightarrow [:\ddot{P}:]^{3-}$

(f) $:Ca \longrightarrow Ca^{2+} + 2e^-$

6.28 (a) If Mg loses two electrons it will have 10 electrons (12 – 2 = 10), which is the same number or electrons as Ne.
(b) If Al loses three electrons it will have 10 electrons (13 – 3 = 10), which is the same number or electrons as Ne.
(f) If Se gains two electrons it will have 36 electrons (34 + 2 = 36), which is the same number of electrons as Kr.
(c) Ne (d) Xe (e) Kr

6.29 Sb is between As and Bi, so the ionization energy will be between 966.5 and 774.0 kJ/mol. The average of these two is 870 kJ/mol, which is a good estimate of the true value 874 kJ/mol.

6.30 Ionization energy increases across the periodic table and decreases down a group.
(a) Sn, at the bottom of the group, has the lowest ionization energy.
(c) Rb is to the left and below the other elements, so it will have the lowest ionization energy.
(b) Se (d) Cl

6.31 Atomic size decreases across the periodic table and increases down a group.
(a) C, at the top of the group, will have the smallest atomic size.
(c) Ca, to the right and above the other elements, will be the smallest.
(b) Kr (d) Ne

6.32 (a) Rn–ionization energy decreases down a group.
(c) Po–density increases down a group.
(e) N–group VA elements gain three electrons to form 3– ions.

6.32 (g) Only H and Ne have no electrons beyond the first energy level and, therefore, are smaller than F.
(b) B (d) Li (f) Ce—Lu

6.33 Element 118 is in group VIIIA, a noble gas. The noble gases are nonmetals, poor conductors of electricity, and colorless. They form few compounds, most of which are covalent and relatively unstable. It would be the largest member of the noble gases, have a low ionization energy and high boiling point.

6.34 (a) Fr, in the bottom left-hand corner of the periodic table would have the lowest ionization energy.
(d) Se, with 34 electrons, would have the same number of electrons as Kr (36) if it gained two.
(e) Te is the only metalloid in group VIA.
(g) Ra–Atomic radius increases down the periodic table.
(i) Zn, Cd, and Hg all have a d^{10} outer electronic configuration. (Cu, Ag, and Au also have an outer electronic configuration of s^1d^{10})
(b) Fr (c) O (f) Bi (h) Th – Lr (j) Al, Ga, In, Tl

6.39 Rb is between K and Cs. The atomic size will be between 0.227 and 0.265 nm. The average of these two values is 0.246 nm, which is very close to 0.25 nm–the accepted value. The density will be between 0.856 and 1.88 g/cm^3. The average of 1.37 g/cm^3 is not to far off from the accepted value 1.53 g/cm^3.

6.47 (c) 5p (d) 3p (e) 4p

6.49 Table 6.2 gives the melting point of silicon as 1414°C and the density as 2.33 g/cm^3.
K = 273 + °C = 273 + 1414 = 1687 K

$$\frac{2.33\ \text{g}}{1\ \text{cm}^3} \times \frac{1000\ \text{cm}^3}{1\ \text{L}} \times \frac{1\ \text{kg}}{1000\ \text{g}} = \frac{2.33\ \text{kg}}{\text{L}}$$

CHAPTER SEVEN

CHEMICAL CALCULATIONS: THE MOLE CONCEPT

7.36 Find the atomic mass in the periodic table for the element and use it with the units g/mol.

(a) $1.000 \text{ mol B} \times \frac{10.81 \text{ g B}}{1 \text{ mol B}} = 10.81 \text{ g B}$

(d) $1.000 \text{ mol Ge} \times \frac{72.61 \text{ g Ge}}{1 \text{ mol Ge}} = 72.61 \text{ g Ge}$

(b) 58.93 g Co (c) 95.94 g Mo (e) 226 g Ra (f) 107.9 g Ag
(g) 232.0 g Th

7.37 Find the number of donuts produced in a year by one person.

$$\frac{365 \text{ days}}{1 \text{ year}} \times \frac{24 \text{ hr}}{1 \text{ day}} \times \frac{60 \text{ minutes}}{1 \text{ hr}} \times \frac{60 \text{ s}}{1 \text{ minute}} \times \frac{10 \text{ donuts}}{1 \text{ s}} = \frac{3.2 \times 10^8 \text{ donuts}}{1 \text{ year}}$$

Now calculate the number of donuts produced at this rate by one-billion people.

$$1 \times 10^9 \text{ people} \times \frac{3.2 \times 10^8 \text{ donuts}}{1 \text{ person}} = 3 \times 10^{17} \text{ donuts}$$

Finally, calculate the length of time required to produce one mole of donuts.

$$6.022 \times 10^{23} \text{ donuts} \times \frac{1 \text{ year}}{3 \times 10^{17} \text{ donuts}} \times \frac{1 \text{ century}}{100 \text{ years}} = 2 \times 10^4 \text{ centuries}$$

7.38 (a) $1.000 \text{ mol B} \times \frac{6.022 \times 10^{23} \text{ atoms B}}{1 \text{ mol B}} = 6.022 \times 10^{23} \text{ atoms B}$

$$1.000 \text{ mol B} \times \frac{10.81 \text{ g B}}{1 \text{ mol B}} = 10.81 \text{ g B}$$

(d) $182.4 \text{ g Zr} \times \frac{1 \text{ mol Zr}}{91.22 \text{ g Zr}} = 2.000 \text{ mol Zr}$

$$2.000 \text{ mol Zr} \times \frac{6.022 \times 10^{23} \text{ atoms Zr}}{1 \text{ mol Zr}} = 1.204 \times 10^{24} \text{ atoms Zr}$$

(f) $6.02 \times 10^{24} \text{ atoms Sn} \times \frac{1 \text{ mol Sn}}{6.02 \times 10^{23} \text{ atoms Sn}} = 10.0 \text{ mol Sn}$

$$10.0 \text{ mol Sn} \times \frac{119 \text{ g Sn}}{1 \text{ mol Sn}} = 1.19 \times 10^3 \text{ g Sn}$$

7.38

Element	Number of Moles	Number of Atoms	Mass, g
(b) Al	0.330	1.99×10^{23}	8.92
(c) Ni	0.100	6.02×10^{22}	5.87
(e) Cs	0.500	3.01×10^{23}	66.5
(g) Ru	1.00	6.02×10^{23}	101
(h) Ca	1.999	1.204×10^{24}	80.16
(i) Bi	3.115	1.876×10^{24}	651.0
(j) Kr	0.148	8.94×10^{22}	12.4

7.39 (a) $0.0145\ \text{g K} \times \frac{1\ \text{mol K}}{39.1\ \text{g K}} = 3.71 \times 10^{-4}\ \text{mol K}$

(c) $87.2\ \text{kg K} \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mol K}}{39.1\ \text{g K}} = 2.23 \times 10^{3}\ \text{mol K}$

(b) 0.256 mol K (d) 0.12788 mol K

7.40 (a) $3.99\ \text{g As} \times \frac{1\ \text{mol As}}{74.9\ \text{g As}} = 0.0533\ \text{mol As}$

(c) $5.66\ \text{mg Ni} \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{1\ \text{mol Ni}}{58.7\ \text{g Ni}} = 9.64 \times 10^{-5}\ \text{mol Ni}$

(b) 0.01108 mol Te (d) 19 mol Ir

7.41 (a) $3.99\ \text{g As} \times \frac{1\ \text{mol As}}{74.9\ \text{g As}} \times \frac{6.022 \times 10^{23}\ \text{atoms As}}{1\ \text{mol As}} = 3.21 \times 10^{22}\ \text{atoms As}$

(c) $5.66\ \text{mg Ni} \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{1\ \text{mol Ni}}{58.7\ \text{g Ni}} \times \frac{6.022 \times 10^{23}\ \text{atoms Ni}}{1\ \text{mol Ni}}$

$= 5.81 \times 10^{19}\ \text{atoms Ni}$

(b) 6.673×10^{21} Te atoms (d) 1.2×10^{25} Ir atoms

7.42 (a) $7.11\ \text{mol Ar} \times \frac{40.0\ \text{g Ar}}{1\ \text{mol Ar}} = 384\ \text{g Ar}$

(c) $9.311\ \text{Mmol Na} \times \frac{1 \times 10^{6}\ \text{mol}}{1\ \text{Mmol}} \times \frac{22.99\ \text{g Na}}{1\ \text{mol Na}} = 2.141 \times 10^{8}\ \text{g Na}$

(b) 0.030 g Li (d) 0.117 g V

7.43 (a) $9.97\ \text{g Pb} \times \frac{1\ \text{mol Pb}}{207\ \text{g Pb}} \times \frac{6.02 \times 10^{23}\ \text{atoms Pb}}{1\ \text{mol Pb}} = 2.90 \times 10^{22}\ \text{atoms Pb}$

7.43 (d) $23.189\ \text{mg Ra} \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{1\ \text{mol Ra}}{226\ \text{g Ra}} \times \frac{6.0220 \times 10^{23}\ \text{atoms Ra}}{1\ \text{mol Ra}}$

$= 6.18 \times 10^{19}$ atoms Ra

(b) 5.255×10^{21} U atoms (c) 2.90×10^{25} Mo atoms

7.44 (a) $5.03 \times 10^{23}\ \text{atoms Xe} \times \frac{1\ \text{mol Xe}}{6.02 \times 10^{23}\ \text{atoms Xe}} = 0.835$ mol Xe

(b) $4.1 \times 10^{24}\ \text{atoms Cu} \times \frac{1\ \text{mol Cu}}{6.0 \times 10^{23}\ \text{atoms Cu}} = 6.8$ mol Cu

(c) 8.834×10^{-4} mol Pd (d) 1.3285×10^{-4} mol Hg

7.45 (a) $3.0 \times 10^{23}\ \text{atoms Kr} \times \frac{1\ \text{mol Kr}}{6.0 \times 10^{23}\ \text{atoms Kr}} \times \frac{84\ \text{g Kr}}{1\ \text{mol Kr}} = 42$ g Kr

(c) $5.36 \times 10^{20}\ \text{atoms Ge} \times \frac{1\ \text{mol Ge}}{6.02 \times 10^{23}\ \text{atoms Ge}} \times \frac{72.6\ \text{g Ge}}{1\ \text{mol Ge}}$

$= 0.0646$ g Ge

(b) 1025.5 g Mg (d) 1.197×10^{7} g Cd

7.46 (a) $3 \times 10^{23}\ \text{atoms Fe} \times \frac{1\ \text{mol Fe}}{6 \times 10^{23}\ \text{atoms Fe}} \times \frac{56\ \text{g Fe}}{1\ \text{mol Fe}} = 3 \times 10^{1}$ g Fe

(b) $5.40 \times 10^{9}\ \text{atoms Fe} \times \frac{1\ \text{mol Fe}}{6.02 \times 10^{23}\ \text{atoms Fe}} \times \frac{55.8\ \text{g Fe}}{1\ \text{mol Fe}}$

$= 5.02 \times 10^{-13}$ g Fe

(c) $711\ \text{atoms Fe} \times \frac{1\ \text{mol Fe}}{6.02 \times 10^{23}\ \text{atoms Fe}} \times \frac{55.8\ \text{g Fe}}{1\ \text{mol Fe}} = 6.59 \times 10^{-20}$ g Fe

(d) $1\ \text{atom Fe} \times \frac{1\ \text{mol Fe}}{6.0220 \times 10^{23}\ \text{atoms Fe}} \times \frac{55.845\ \text{g Fe}}{1\ \text{mol Fe}}$

$= 9.2735 \times 10^{-23}$ g Fe

7.48 (a) $67.5\ \text{mg Re} \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{1\ \text{mol Re}}{186\ \text{g Re}} = 3.62 \times 10^{-4}$ mol Re

(b) $2.000\ \text{kg Pd} \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mol Pd}}{106.4\ \text{g Pb}} \times \frac{6.022 \times 10^{23}\ \text{atoms Pd}}{1\ \text{mol Pd}}$

$= 1.132 \times 10^{25}$ atoms Pd

(c) $1\ \text{atom Hf} \times \frac{1\ \text{mol Hf}}{6 \times 10^{23}\ \text{atom Hf}} = 2 \times 10^{-24}$ mol Hf

(d) $0.001160\ \text{mmol Bi} \times \frac{1\ \text{mol}}{1000\ \text{mmol}} \times \frac{209.0\ \text{g Bi}}{1\ \text{mol Bi}} \times \frac{1000\ \text{mg}}{1\ \text{g}}$

$= 0.2424$ mg Bi

(e) $3.66 \times 10^{26}\ \text{atoms Nb} \times \frac{1\ \text{mol Nb}}{6.022 \times 10^{23}\ \text{atoms Nb}} \times \frac{92.9\ \text{g Nb}}{1\ \text{mol Nb}} \times \frac{1\ \text{kg}}{1000\ \text{g}}$

$= 56.5$ kg Nb

7.50 (a) $25.9\ \cancel{\text{mg Pt}} \times \frac{1\ \text{g}}{1000\ \cancel{\text{mg}}} \times \frac{1\ \text{mol Pt}}{195\ \cancel{\text{g Pt}}} \times \frac{6.02 \times 10^{23}\ \text{atoms Pt}}{1\ \cancel{\text{mol Pt}}}$

$= 8.00 \times 10^{19}$ atoms Pt

(b) $1.51 \times 10^{-2}\ \cancel{\text{g Pd}} \times \frac{1\ \text{mol Pd}}{106\ \cancel{\text{g Pd}}} \times \frac{6.02 \times 10^{23}\ \text{atoms Pd}}{1\ \cancel{\text{mol Pd}}}$

$= 8.58 \times 10^{19}$ atoms Pd

(c) $7.79\ \cancel{\text{mg Ni}} \times \frac{1\ \text{g}}{1000\ \cancel{\text{mg}}} \times \frac{1\ \text{mol Ni}}{58.7\ \cancel{\text{g Ni}}} \times \frac{6.02 \times 10^{23}\ \text{atoms Ni}}{1\ \cancel{\text{mol Ni}}}$

$= 7.99 \times 10^{19}$ atoms Ni

(d) $2.62 \times 10^{4}\ \cancel{\mu\text{g Au}} \times \frac{1 \times 10^{-6}\ \text{g}}{1\ \cancel{\mu\text{g}}} \times \frac{1\ \text{mol Au}}{197\ \cancel{\text{g Au}}} \times \frac{6.02 \times 10^{23}\ \text{atoms Au}}{1\ \cancel{\text{mol Au}}}$

$= 8.01 \times 10^{19}$ atoms Au

The order is (b) > (d) > (a) > (c)

7.51 (a) 127(I) + 80(Br) = 207 g/mol IBr
(d) 12(C) + 4 × 127(4I) = 520 g/mol CI_4
(e) 2 × 32(2S) + 2 × 19(2F) = 102 g/mol S_2F_2
(h) 2 × 1(2H) + 2 × 32(2S) + 8 × 16(8O) = 194 g/mol $H_2S_2O_8$
(b) 30.0 g/mol NO (c) 160 g/mol Br_2 (f) 207 g/mol XeF_4
(g) 258 g/mol $BrCl_5$

7.52 (a) 4 × 30.97(4P) + 6 × 16.0(6O) = 219.9 g/mol P_4O_6
(c) 16.0(O) + 2 × 79.9(2Br) = 175.8 g/mol OBr_2
(f) 2 × 1.008(2H) + 2 × 12.01(2C) + 4 × 16.00(4O) = 90.04 g/mol $H_2C_2O_4$
(b) 394.7 g/mol NI_3 (d) 223.3 g/mol $XeOF_4$ (e) 108.0 g/mol N_2O_5
(g) 153.5 g/mol $POCl_3$ (h) 342.2 g/mol $C_{12}H_{22}O_{11}$

7.53 (a) $1.000\ \cancel{\text{mol SO}_2} \times \frac{64.05\ \text{g SO}_2}{1\ \cancel{\text{mol SO}_2}} = 64.05\ \text{g SO}_2$

$1.000\ \cancel{\text{mol SO}_2} \times \frac{6.022 \times 10^{23}\ \text{molecules SO}_2}{1\ \cancel{\text{mol SO}_2}}$

$= 6.022 \times 10^{23}$ molecules SO_2

(d) $6.02 \times 10^{21}\ \cancel{\text{molecules H}_2\text{SO}_3} \times \frac{1\ \text{mol H}_2\text{SO}_3}{6.02 \times 10^{23}\ \cancel{\text{molecules H}_2\text{SO}_3}}$

$= 0.0100$ mol H_2SO_3

$6.02 \times 10^{21}\ \cancel{\text{molecules H}_2\text{SO}_3} \times \frac{1\ \cancel{\text{mol H}_2\text{SO}_3}}{6.02 \times 10^{23}\ \cancel{\text{molecules H}_2\text{SO}_3}} \times \frac{82.0\ \text{g H}_2\text{SO}_3}{1\ \cancel{\text{mol H}_2\text{SO}_3}} = 0.820\ \text{g H}_2\text{SO}_3$

(f) $34.9\ \cancel{\text{g AlCl}_3} \times \frac{1\ \text{mol AlCl}_3}{133\ \cancel{\text{g AlCl}_3}} = 0.262$ mol $AlCl_3$

$34.9\ \cancel{\text{g AlCl}_3} \times \frac{1\ \cancel{\text{mol AlCl}_3}}{133\ \cancel{\text{g AlCl}_3}} \times \frac{6.02 \times 10^{23}\ \text{molecules AlCl}_3}{1\ \cancel{\text{mol AlCl}_3}}$

$= 1.58 \times 10^{23}$ molecules $AlCl_3$

7.53

Compound	Number of Moles	Number of Molecules	Mass, g
(b) BrF	0.34	2.0×10^{23}	34
(c) NCl_3	0.175	1.05×10^{23}	21.0
(e) N_2O_5	1.601	9.641×10^{23}	172.9
(g) PBr_5	0.12944	7.7946×10^{22}	55.721
(h) OF_2	3.030	1.825×10^{24}	163.6
(i) SO_3	136	8.21×10^{25}	1.09×10^4
(j) C_5H_{12}	12.5	7.54×10^{24}	902

7.54 (a) $0.00344 \text{ mol } ClO_2 \times \frac{67.5 \text{ g } ClO_2}{1 \text{ mol } ClO_2} = 0.232 \text{ g } ClO_2$

(e) $1.110 \text{ mmol } N_2O_4 \times \frac{1 \text{ mol}}{1000 \text{ mmol}} \times \frac{92.01 \text{ g } N_2O_4}{1 \text{ mol } N_2O_4} = 0.1021 \text{ g } N_2O_4$

(b) 459 g HBr (c) 0.038 g SeO_2 (d) 3×10^2 g H_2SO_4

7.55 (a) $6.2 \text{ g } H_2O_2 \times \frac{1 \text{ mol } H_2O_2}{34 \text{ g } H_2O_2} \times \frac{6.0 \times 10^{23} \text{ molecules } H_2O_2}{1 \text{ mol } H_2O_2}$

$= 1.1 \times 10^{23}$ molecules H_2O_2

(b) $0.04499 \text{ g } ClF_3 \times \frac{1 \text{ mol } ClF_3}{92.45 \text{ g } ClF_3} \times \frac{6.022 \times 10^{23} \text{ molecules } ClF_3}{1 \text{ mol } ClF_3}$

$= 2.931 \times 10^{20}$ molecules ClF_3

(c) 2.35×10^{23} N_2H_4 molecules (d) 4.8×10^{22} H_3PO_4 molecules

(e) 4.3143×10^{25} ClF molecules

7.56 (a) $8.207 \text{ mol } H_2O \times \frac{1 \text{ mol O}}{1 \text{ mol } H_2O} = 8.207 \text{ mol O}$

(c) $0.00349 \text{ g } P_2O_5 \times \frac{1 \text{ mol } P_2O_5}{142 \text{ g } P_2O_5} \times \frac{5 \text{ mol O}}{1 \text{ mol } P_2O_5} = 1.23 \times 10^{-4} \text{ mol O}$

(b) 9.0 mol O (d) 0.8 mol O

7.57 (a) $0.37 \text{ mol } H_2SO_4 \times \frac{2 \text{ mol H}}{1 \text{ mol } H_2SO_4} \times \frac{1.0 \text{ g H}}{1 \text{ mol H}} = 0.75 \text{ g H}$

(b) $5.92 \text{ mg } SiH_4 \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol } SiH_4}{32.1 \text{ g } SiH_4} \times \frac{4 \text{ mol H}}{1 \text{ mol } SiH_4} \times \frac{1.01 \text{ g H}}{1 \text{ mol H}}$

$= 7.43 \times 10^{-4}$ g H

7.57 (c) 5.912×10^{23} ~~molecules C_8H_{16}~~ $\times \frac{1 \text{ mol } C_8H_{16}}{6.022 \times 10^{23} \text{ molecules } C_8H_{16}}$

$\times \frac{16 \text{ mol H}}{1 \text{ mol } C_8H_{16}} \times \frac{1.008 \text{ g H}}{1 \text{ mol H}} = 15.83 \text{ g H}$

(d) 23.775 ~~kg $B_{10}H_{14}$~~ $\times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol } B_{10}H_{14}}{122.21 \text{ g } B_{10}H_{14}} \times \frac{14 \text{ mol H}}{1 \text{ mol } B_{10}H_{14}}$

$\times \frac{1.0079 \text{ g H}}{1 \text{ mol H}} = 2745.1 \text{ g H}$

7.60 (a) 159 ~~mg PCl_5~~ $\times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol } PCl_5}{137 \text{ g } PCl_5} \times \frac{1 \text{ mol P}}{1 \text{ mol } PCl_5} \times \frac{6.02 \times 10^{23} \text{ atoms P}}{1 \text{ mol P}}$

$= 6.97 \times 10^{20}$ atoms P

(b) 2.96×10^{-5} ~~kg P_4O_{10}~~ $\times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol } P_4O_{10}}{284 \text{ g } P_4O_{10}} \times \frac{4 \text{ mol P}}{1 \text{ mol } P_4O_{10}} \times$

$\frac{6.02 \times 10^{23} \text{ atom P}}{1 \text{ mol P}} = 2.51 \times 10^{20}$ atoms P

(c) 0.120 ~~mol P_4O_6~~ $\times \frac{4 \text{ mol P}}{1 \text{ mol } P_4O_6} \times \frac{6.02 \times 10^{23} \text{ atom P}}{1 \text{ mol P}}$

$= 2.89 \times 10^{23}$ atoms P

(d) 0.120 ~~mol H_3PO_3~~ $\times \frac{1 \text{ mol P}}{1 \text{ mol } H_3PO_3} \times \frac{6.02 \times 1023 \text{ atoms P}}{1 \text{ mol P}}$

$= 7.23 \times 10^{22}$ atoms P

The order is (c) > (d) > (a) > (b)

7.61 (a) $63.5(Cu) + 35.5(Cl) = 99.0$ g/mol CuCl
(c) $65.4(Zn) + 2 \times 14.0(2N) + 6 \times 16.0(6O) = 189$ g/mol $Zn(NO_3)_2$
(e) $2 \times 55.8(2Fe) + 3 \times 32.0(3S) + 12 \times 16.0(12O) = 400$ g/mol $Fe_2(SO_4)_3$
(b) 294 g/mol CaI_2 (d) 110 g/mol Li_2SO_4

7.62 (a) 47 ~~g $NaClO_3$~~ $\times \frac{1 \text{ mol } NaClO_3}{106 \text{ g } NaClO_3} = 0.44$ mol $NaClO_3$

(b) 700.0 ~~mg $Ca_3(PO_4)_2$~~ $\times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol } Ca_3(PO_4)_2}{310.2 \text{ g } Ca_3(PO_4)_2}$

$= 0.002257$ mol $Ca_3(PO_4)_2$

(c) 47.2 mol $RbBrO_2$

7.63 (a) 9.55 ~~mol TiO_2~~ $\times \frac{79.9 \text{ g } TiO_2}{1 \text{ mol } TiO_2} = 763$ g TiO_2

(b) 7.07 ~~mol K_2SnCl_6~~ $\times \frac{410 \text{ g } K_2SnCl_6}{1 \text{ mol } K_2SnCl_6} = 2.90 \times 10^3$ g $K_2(SnCl_6)$

(c) 0.004529 ~~mmol PbC_2O_4~~ $\times \frac{1 \text{ mol}}{1000 \text{ mmol}} \times \frac{295.2 \text{ g } PbC_2O_4}{1 \text{ mol } PbC_2O_4}$

$= 0.001337$ g PbC_2O_4

7.64 (a) $9.34\ \text{g } MgSiO_3 \times \frac{1\ \text{mol } MgSiO_3}{100\ \text{g } MgSiO_3} \times \frac{6.02 \times 10^{23}\ \text{formula units } MgSiO_3}{1\ \text{mol } MgSiO_3}$

$= 5.62 \times 10^{22}$ formula units $MgSiO_3$

(b) $5.8\ \text{kg } Hg_2(NO_2)_2 \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mol } Hg_2(NO_2)_2}{492\ \text{g } Hg_2(NO_2)_2} \times \frac{6.0 \times 10^{23}\ \text{formula units } Hg_2(NO_2)_2}{1\ \text{mol } Hg_2(NO_2)_2}$

$= 7.1 \times 10^{24}$ formula units $Hg_2(NO_2)_2$

(c) $234.0\ \text{mmol } NH_4C_2H_3O_2 \times \frac{1\ \text{mol}}{1000\ \text{mmol}} \times \frac{6.022 \times 10^{23}\ \text{formula units } NH_4C_2H_3O_2}{1\ \text{mol } NH_4C_2H_3O_2}$

$= 1.409 \times 10^{23}$ formula units $NH_4C_2H_3O_2$

(d) 3.7×10^{19} $NaHPO_4$ formula units

7.65 (a) % H = (g H/g HI) × 100 = (1.01 g H/128 g HI) × 100 = 0.788% H

% I = (g I/g HI) × 100 = (127 g I/128 g HI) × 100 = 99.2% I

(c) % Hg = (g Hg/g Hg_2I_2) × 100 = (401 g Hg/655 g Hg_2I_2) × 100 = 61.2% Hg

% I = (g I/g Hg_2I_2) × 100 = (254 g I/655 g Hg_2I_2) × 100 = 38.8% I

(e) % Os = (g Os/g OsO_5) × 100 = (190 g Os/ 270 g OsO_5) × 100 = 70.4% Os

% O = (g O/g OsO_5) × 100 = (80.0 g O/270 g OsO_5) × 100 = 29.6% O

(b) 43.2% Mg, 56.8% S (d) 60.2% Si, 40.0% N

7.66 (a) % K = (g K/g$KMnO_4$) × 100 = (39.10 g K/158.0 g $KMnO_4$) × 100 = 24.74% K

% Mn = (g Mn/g $KMnO_4$) × 100 = (54.94 g Mn/158.0 g $KMnO_4$) × 100 = 34.77% Mn

% O = (g O/g $KMnO_4$) × 100 = (64.00 g O/158.0 g $KMnO_4$) × 100 = 40.49% O

(c) % Ba =(g Ba/g $Ba(NO_2)_2$) × 100 = (137.3 g Ba/229.3 g $Ba(NO_2)_2$) × 100 = 59.89% Ba

% N = (g N/g $Ba(NO_2)_2$) × 100 = (28.01 g N/229.3 g $Ba(NO_2)_2$) × 100 = 12.21% N

% O = (g O/g $Ba(NO_2)_2$)) × 100 = (64.00 g 0/229.3 g $Ba(NO_2)_2$) × 100 = 27.91% O

(e) % N = (g N/g $(NH_4)_2Cr_2O_7$) × 100

= (28.01 g N/252.0 g $(NH_4)_2Cr_2O_7$) × 100 = 11.11% N

% H = (g H/g $(NH_4)_2Cr_2O_7$) × 100

= (8.063 g H/252.0 g $(NH_4)_2Cr_2O_7$) × 100 = 3.200% H

7.66 (e) % Cr = (g Cr/g $(NH_4)_2Cr_2O_7$) × 100

= (104.0 g Cr/252.0 g $(NH_4)_2Cr_2O_7$) × 100 = 41.27% Cr

% O = (g O/g $(NH_4)_2Cr_2O_7$) × 100

= (112.0 g O/252.0 g $(NH_4)_2Cr_2O_7$) × 100 = 44.44% 0

(b) 39.06% K, 1.007% H, 12.00% C, 47.95% O

(d) 34.39% Ni, 28.12% C, 37.49% O

7.67 (a) % Ag = (g Ag/g Ag_2S) × 100 = (216 g Ag/248 g Ag_2S) × 100 = 87.1% Ag

(d) % Ag = (g Ag/g Ag_3AsS_3) × 100 = (324 g Ag/495 g Ag_3AsS_3) × 100

= 65.4% Ag

(b) 38.2% Ag (c) 65.1% Ag

7.69 (a) % H_2O = (g H_2O/g $CuSO_4 \cdot 5H_2O$) × 100

= (90.08 g H_2O/249.7 g $CuSO_4 \cdot 5H_2O$) × 100 = 36.07% H_2O

(c) % H_2O = (g H_2O/g $LiClO_4 \cdot 3H_2O$) × 100

= (54.05 g H_2O/160.4 g $LiC1O_4$) × 100 = 33.69% H_2O

(b) 14.76% H_2O (d) 15.00% H_2O

7.71 First calculate the moles of each element per 100 g of compound. Then calculate the smallest whole–number ratio.

(a) 46.55 ~~g Fe~~ × 1 mol Fe/55.85 ~~g Fe~~ = 0.8335 mol Fe

53.45 ~~g S~~ × 1 mol S/32.06 ~~g S~~ = 1.670 mol S

0.8335 ~~mol Fe~~/0.8335 ~~mol Fe~~ = 1.000

1.670 mol S/0.8335 mol Fe = 2.00 mol S/1 mol Fe

The empirical formula is FeS_2.

(d) 5.24 ~~g Si~~ × 1 mol Si/28.1 ~~g Si~~ = 0.186 mol Si

94.76 ~~g I~~ × 1 mol I/126.9 ~~g I~~ = 0.7467 mol I

0.186.~~mol Si~~/0.186 ~~mol Si~~ = 1.00

0.7467 mol I/0.186 mol Si = 4.01 mol I/1 mol Si

The empirical formula is SiI_4.

(f) 76.62 ~~g Ce~~ × 1 mol Ce/140.1 ~~g Ce~~ = 0.5469 mol Ce

23.38 ~~g S~~ × 1 mol S/32.06 ~~g S~~ = 0.7293 mol S

0.5469 ~~mol Ce~~/0.5469 ~~mol Ce~~ = 1.000

0.7293 mol S/0.5469 mol Ce = 1.33 mol S/1 mol Ce

Multiply each ratio by 3 to obtain whole number ratios.

1.000 mol Ce × 3 = 3 mol Ce

1.33 mol S × 3 = 4 mol S

The empirical formula is Ce_3S_4

(b) NO (c) CH_3 (e) NCl_3

7.72 (a) 60.1 ~~g K~~ × 1 mol K/39.li ~~g K~~ = 1.54 mol K
18.4 ~~g C~~ × 1 mol C/l2.0 ~~g C~~ = 1.53 mol C
21.5 ~~g N~~ × 1 mol N/14.0 ~~g N~~ =1.54 mol N
1.54 ~~mol K~~/1.54 ~~mol K~~ = 1.00
1.53 mol C/1.54 mol K = 1.0 mol C/1 mol K
1.54 mol N/1.54 mol K = 1.0 mol N/1 mol K
The empirical formula is KCN

(b) 70.2 ~~g Pb~~ × 1 mol Pb/207 ~~g Pb~~ = 0.339 mol Pb
8.1 ~~g C~~ × 1 mol C/12 ~~g C~~ = 0.68 mol C
21.7 ~~g O~~ × 1 mol O/16.0 ~~g O~~ = 1.36 mol O
0.339 ~~mol Pb~~/0.339 ~~mol Pb~~ = 1.00
0.68 mol C/0.339 mol Pb = 2.0 mol C/1 mol Pb
1.36 mol O/0.339 mol Pb = 4.01 mol O/1 mol Pb
The empirical formula is PbC_2O_4.

(e) 18.79 ~~g Li~~ × 1 mol Li/6.941 ~~g Li~~ = 2.707 mol Li
16.24 ~~g C~~ × 1 mol C/12.0 ~~g C~~ = 1.353 mol C
64.97 ~~g O~~ × 1 mol O/16.0 ~~g O~~ = 4.061 mol O
l.353 ~~mol C~~ /1.353 ~~mol C~~ = 1.000
2.707 mol Li/1.353 mol C = 2.001 mol Li/1 mol C
4.061 mol O/1.353 mol C = 3.001 mol O/1 mol C
The empirical formula is Li_2CO_3.

(c) Cu_2SF_6 (d) CH_2Br_2

7.73 25.0 g sample – 13.0 g Cr = 12.0 g O.
13.0 ~~g Cr~~ × 1 mol Cr/52.0 ~~g Cr~~ = 0.250 mol Cr
12.0 ~~g O~~ × 1 mol O/16.0 ~~g O~~ = 0.750 mol O
0.250 ~~mol Cr~~/0.250 ~~mol Cr~~ = 1.00
0.750 mol O/0.250 mol Cr = 3.00 mol O/1 mol Cr
The empirical formula is CrO_3.

7.75 16.0 ~~g C~~ × 1 mol C/12.0 ~~g C~~ = 1.33 mol C
18.7 ~~g N~~ × 1 mol N/14.0 ~~g N~~ = 1.34 mol N
5.3 ~~g H~~ × 1 mol H/l.0 ~~g H~~ = 5.3 mol H
1.33 ~~mol C~~/1.33 ~~mol C~~ = 1.00
1.34 mol N/l.33 mol C = 1.00 mol N/1 mol C
5.3 mol H/1.33 mol C = 4.0 mol H/1 mol C
The empirical formula is CNH_4.

7.77 28.2 ~~g N~~ × 1 mol N/14.0 ~~g N~~ = 2.01 mol N
20.8 ~~g P~~ × 1 mol P/31.0 ~~g P~~ = 0.671 mol P
42.9 ~~g O~~ × 1 mol O/16.0 ~~g O~~ = 2.68 mol O
8.1 ~~g H~~ × 1 mol H/1.0 ~~g H~~ = 8.1 mol H

7.77 0.671 ~~mol P~~/0.671 ~~mol P~~ = 1.00
2.01 mol N/0.671 mol P = 3.00 mol N/1 mol P
2.68 mol O/0.671 mol P = 4.00 mol O/1 mol P
8.1 mol H/0.671 mol P = 12 mol H/l mol P
The empirical formula is $PN_3O_4H_{12} = (NH_4)_3PO_4$.

7.79 85.7 ~~g C~~ × 1 mol C/12.0 ~~g C~~ = 7.14 mol C
14.3 ~~g H~~ × 1 mol H/1.01 ~~g H~~ = 14.2 mol H
7.14 ~~mol C~~ /7.14 ~~mol C~~ = 1.00
14.2 mol H/7.14 mol C = 1.99 mol H/1 mol C
The empirical formula is CH_2
Empirical formula mass = 14.0 g/mol
Mol. mass/Empirical formula mass = 168/14.0 = 12
Twelve formula units compose the total molecular mass. The molecular formula is 12 × CH_2, or $C_{12}H_{24}$

7.82 11.843 ~~g B~~ × 1 mol B/10.81 ~~g B~~ = 1.096 mol B
0.885 ~~g H~~ × 1 mol H/1.01 ~~g H~~ = 0.876 mol H
0.876 ~~mol H~~/ 0.876 ~~mol H~~ 1.00
1.096 mol B/0.876 mol H = 1.25 mol B/1 mol H
1.00 mol H × 4 = 4.00 mol H
1.25 mol B × 4 = 5.00 mol B
The empirical formula is B_5H_4.
Empirical formula mass = 58.08 g/mol
Mol. mass/Empirical formula mass = 232.4/58.08 = 4.00
Four formula units compose the total molecular mass. The molecular formula is 4 × B_5H_4, or $B_{20}H_{16}$.

7.84 3.824 g sample – 2.750 g C – 0.463 g H = 0.611 g O
0.611 ~~g O~~ × 1 mol O/16.0 ~~g O~~ = 0.0382 mol O
2.750 ~~g C~~ × 1 mol C/12.01 ~~g C~~ = 0.2290 mol C
0.463 ~~g H~~ × 1 mol H/1.01 ~~g H~~ = 0.458 mol H
0.0382 ~~mol O~~/0.0382 ~~mol O~~ = 1.00
0.2290 mol C/0.0382 mol O = 5.995 mol C/1 mol O
0.458 mol H/0.0382 mol O = 12.0 mol H/1 mol O
The empirical formula is $C_6H_{12}O$.
Empirical formula mass = 100.0 g/mol
Mol. mass/Empirical formula mass = 200/100 = 2
Two formula units compose the total molecular mass. The molecular formula is 2 × $C_6H_{12}O$, or $C_{12}H_{24}O_2$.

7.87 (a) $399\ \cancel{\text{g solution}} \times \frac{2.95\ \text{g NaNO}_2}{100\ \cancel{\text{g solution}}} = 11.8\ \text{g NaNO}_2$

399 g solution – 11.8 g $NaNO_2$ = 387 g H_2O

To prepare a 2.95% m/m $NaNO_2$ solution, dissolve 11.8 g $NaNO_2$ in 387 g H_2O.

(b) 0.574 g LiOH and 43.2 g H_2O (c) 1.12 g NH_4ClO_3 and 3.77 kg H_2O

7.88 (a) $4.44\ \cancel{\text{g HCl}} \times \frac{100\ \text{g solution}}{37.0\ \cancel{\text{g HCl}}} = 12.0\ \text{g solution}$

(c) $0.188\ \cancel{\text{kg HCl}} \times \frac{1000\ \cancel{\text{g}}}{1\ \cancel{\text{kg}}} \times \frac{100\ \text{g solution}}{37\ \cancel{\text{g HCl}}} = 508\ \text{g solution}$

(b) 1.46×10^3 g solution (d) 0.0106 g solution

7.90 $5.05\ \cancel{\text{g KI}} \times \frac{100\ \text{g solution}}{2.10\ \cancel{\text{g KI}}} = 240\ \text{g solution}$

7.92 Mass of solution = 6.53 g solute + 284 g water = 291 g solution

$\frac{6.53\ \text{g solute}}{291\ \text{g solution}} \times 100 = 2.25\%\ \text{m/m}$

7.94 (a) $50.0\ \cancel{\text{mL solution}} \times \frac{1\ \cancel{\text{L}}}{1000\ \cancel{\text{mL}}} \times \frac{0.232\ \cancel{\text{mol Mg(NO}_3)_2}}{1\ \cancel{\text{L solution}}} \times \frac{148\ \text{g Mg(NO}_3)_2}{1\ \cancel{\text{mol Mg(NO}_3)_2}}$

$= 1.72\ \text{g Mg(NO}_3)_2$

To prepare 0.232 M $Mg(NO_3)_2$, dissolve 1.72 g $Mg(NO_3)_2$ in water and dilute to a total volume of 50.0 mL.

(b) $210.0\ \cancel{\text{mL solution}} \times \frac{1\ \cancel{\text{L}}}{1000\ \cancel{\text{mL}}} \times \frac{0.1919\ \cancel{\text{mol NH}_3}}{1\ \cancel{\text{L solution}}} \times \frac{17.03\ \text{g NH}_3}{1\ \cancel{\text{mol NH}_3}}$

$= 0.6863\ \text{g NH}_3$

To prepare 0.1919 M NH_3, dissolve 0.6863 g NH_3 in water and dilute to a total volume of 210.0 mL.

(c) Dissolve 2.12×10^3 $C_6H_{12}O_6$ in water and dilute to 5.66 L.

(d) Dissolve 3.74×10^6 g H_3PO_3 in water and dilute 9.11×10^6 mL.

7.95 L solution = $180.0\ \cancel{\text{mL}} \times (1\ \text{L}/1000\ \cancel{\text{mL}}) = 0.1800\ \text{L}$

(a) $\frac{1.441\ \text{mol (NH}_4)_2\text{SO}_4}{0.1800\ \text{L solution}} = 8.006\ \text{M (NH}_4)_2\text{SO}_4$

(d) $8.331\ \cancel{\text{mg HBr}} \times \frac{1\ \text{g}}{1000\ \cancel{\text{mg}}} \times \frac{1\ \text{mol HBr}}{80.91\ \cancel{\text{g HBr}}} = 1.030 \times 10^{-4}\ \text{mol HBr}$

$\frac{1.030 \times 10^{-4}\ \text{mol HBr}}{0.1800\ \text{L solution}} = 5.720 \times 10^{-4}\ \text{M HBr}$

(b) 0.01479 M $Cu(NO_3)_2$ (c) 0.699 M H_2SO_4

7.96 (a) $5.42\ \text{g}\ C_2H_6O \times \frac{1\ \text{mol}\ C_2H_6O}{46.1\ \text{g}\ C_2H_6O} = 0.118\ \text{mol}\ C_2H_6O$

$82.8\ \text{mL} \times (1\ \text{L}/1000\ \text{mL}) = 0.0828\ \text{L}$

$\frac{0.118\ \text{mol}\ C_2H_6O}{0.0828\ \text{L solution}} = 1.42\ M\ C_2H_6O$

(d) $8.90\ \text{kg}\ NH_4Cl \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mol}\ NH_4Cl}{53.5\ \text{g}\ NH_4Cl} = 166\ \text{mol}\ NH_4Cl$

$\frac{166\ \text{mol}\ NH_4Cl}{526\ \text{L solution}} = 0.316\ M\ NH_4Cl$

(b) $2.25 \times 10^{-3}\ M\ Na_2SO_4$ (c) $0.1446\ M\ K_2CO_3$

7.97 (a) 70% m/m HNO_3 = 70 g HNO_3/100 g solution

$70\ \text{g}\ HNO_3 \times \frac{1\ \text{mol}\ HNO_3}{63\ \text{g}\ HNO_3} = 1.1\ \text{mol}\ HNO_3$

$100\ \text{g solution} \times \frac{1\ \text{cm}^3\ \text{solution}}{1.42\ \text{g solution}} \times \frac{1\ \text{L}}{1000\ \text{cm}^3} = 0.070\ \text{L solution}$

$\frac{1.1\ \text{mol}\ HNO_3}{0.070\ \text{L solution}} = 16\ M\ HNO_3$

(b) $6.3\ M\ C_2H_4O_2$

7.98 (a) Calculate the total number of moles of HCl.

$1.50\ \text{L} \times \frac{15.9\ \text{mol}\ HNO_3}{1\ \text{L}} = 23.8\ \text{mol}\ HNO_3$

Find the volume of 13.9 M HNO_3 which contains 23.8 mol HNO_3.

$23.8\ \text{mol}\ HNO_3 \times \frac{1\ \text{L}}{13.9\ \text{mol}\ HNO_3} = 1.77\ \text{L}$

(b) 9.52 L (c) 6.82×10^3 L

7.99 (a) One inole of RbOH produces two moles of solute particles, 1 mole Rb^+ and 1 mol OH^-.

$287\ \text{mL} \times \frac{1\ \text{L}}{1000\ \text{mL}} \times \frac{0.444\ \text{mol RbOH}}{1\ \text{L}} \times \frac{2\ \text{mol particles}}{1\ \text{mol RbOH}}$

$= 0.255\ \text{mol particles}$

(b) 3.94×10^{-4} mol particles (c) 4.265×10^3 mol particles

7.101 (a) 27% H_2SO_4 m/m = 27 g H_2SO_4/100 g solution

$27\ \text{g}\ H_2SO_4 \times \frac{1\ \text{mol}\ H_2SO_4}{98\ \text{g}\ H_2SO_4} = 0.28\ \text{mol}\ H_2SO_4$

$100\ \text{g solution} \times \frac{1\ \text{cm}^3\ \text{solution}}{1.2\ \text{g solution}} \times \frac{1\ \text{L}}{1000\ \text{cm}^3} = 0.083\ \text{L solution}$

$\frac{0.28\ \text{mol}\ H_2SO_4}{0.083\ \text{L solution}} = 3.3\ M\ H_2SO_4$

7.101 (b) 1.0% K_2SO_4 = 1.0 g K_2SO_4/100 g solution

$$1.0 \text{ g } K_2SO_4 \times \frac{1 \text{ mol } K_2SO_4}{174 \text{ g } K_2SO_4} = 0.0057 \text{ mol } K_2SO_4$$

$$100 \text{ g solution} \times \frac{1 \text{ cm}^3 \text{ solution}}{1.01 \text{ g solution}} \times \frac{1 \text{ L}}{1000 \text{ cm}^3} = 0.0990 \text{ L solution}$$

$$\frac{0.0057 \text{ mol } K_2SO_4}{0.0990 \text{ L solution}} = 0.058 \text{ M } K_2SO_4$$

(c) 12.0% KOH = 12.0 g KOH/100 g solution

$$12.0 \text{ g KOH} \times \frac{1 \text{ mol KOH}}{56.1 \text{ g KOH}} = 0.214 \text{ mol KOH}$$

$$100 \text{ g solution} \times \frac{1 \text{ cm}^3 \text{ solution}}{1.09 \text{ g solution}} \times \frac{1 \text{ L}}{1000 \text{ cm}^3} = 0.0917 \text{ L solution}$$

$$\frac{0.214 \text{ mol } H_2SO_4}{0.0917 \text{ L solution}} = 2.33 \text{ M } H_2SO_4$$

(d) 5.00% $K_2Cr_2O_7$ = 5.00 g $K_2Cr_2O_7$/100 g solution

$$5.00 \text{ g } K_2Cr_2O_7 \times \frac{1 \text{ mol } K_2Cr_2O_7}{294 \text{ g } K_2Cr_2O_7} = 0.170 \text{ mol } K_2Cr_2O_7$$

$$100 \text{ g solution} \times \frac{1 \text{ cm}^3 \text{ solution}}{1.03 \text{ g solution}} \times \frac{1 \text{ L}}{1000 \text{ cm}^3} = 0.0971 \text{ L solution}$$

$$\frac{0.170 \text{ mol } K_2Cr_2O_7}{0.0971 \text{ L solution}} = 0.175 \text{ M } K_2Cr_2O_7$$

7.103

$$182.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.5000 \text{ mol HI}}{1 \text{ L}} = 0.09100 \text{ mol HI}$$

$$0.09100 \text{ mol HI} \times \frac{1 \text{ L}}{0.2949 \text{ mol HI}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 308.6 \text{ mL}$$

7.106 (a)

$$9.971 \text{ g KOH} \times \frac{1 \text{ mol KOH}}{56.11 \text{ g KOH}} \times \frac{6.022 \times 10^{23} \text{ formula units KOH}}{1 \text{ mol KOH}}$$

$$= 1.070 \times 10^{23} \text{ formula units KOH}$$

$$1.070 \times 10^{23} \text{ formula units } Na_3PO_4 \times \frac{1 \text{ mol } Na_3PO_4}{6.022 \times 10^{23} \text{ formula units } Na_3PO_4}$$

$$\times \frac{163.9 \text{ g } Na_3PO_4}{1 \text{ mol } Na_3PO_4} = 29.13 \text{ g } Na_3PO_4$$

(b) 10.71 g Na_3PO_4

7.108 Treat each compound as if it were an element and find the number of moles and the mole ratio for each one.

$$60.7 \text{ g } SiO_2 \times \frac{1 \text{ mol } SiO_2}{60.1 \text{ g } SiO_2} = 1.01 \text{ mol } SiO_2$$

$$27.2 \text{ g MgO} \times \frac{1 \text{ mol MgO}}{40.3 \text{ g MgO}} = 0.675 \text{ mol MgO}$$

$$12.1 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.0 \text{ g } H_2O} = 0.672 \text{ mol } H_2O$$

$$0.672 \text{ mol } H_2O / 0.672 \text{ mol } H_2O = 1.00$$

7.108 0.675 mol MgO/0.672 mol H_2O = 1.00 mol MgO/1 mol H_2O
1.01 mol SiO_2/0.672 mol H_2O = 1.50 mol SiO_2/1 mol H_2O
1.00 mol H_2O × 2 = 2.00 mol H_2O
1.00 mol MgO × 2 = 2.00 mol MgO
1.50 mol SiO_2 × 2 = 3.00 mol SiO_2
The empirical formula is $Mg_2Si_3H_4O_{10}$

7.110 0.459 ~~g C~~ × 1 mol C/12.0 ~~g C~~ = 0.0383 mol C
0.0275 ~~g H~~ × 1 mol H/1.01 ~~g H~~ = 0.0272 mol H
0.262 ~~g O~~ × 1 mol O/16.0 ~~g O~~ = 0.0164 mol O
0.175 ~~g S~~ × 1 mol S/32.0 ~~g S~~ = 0.00547 mol S
0.0765 ~~g N~~ × 1 mol N/14.0 ~~g N~~ = 0.00546 mol N
0.00546 ~~mol N~~/0.00546 ~~mol N~~ = 1.00
0.00547 mol S/0.00546 mol N = 1.00 mol S/1 mol N
0.0164 mol O/0.00546 mol N = 3.00 mol O/1 mol N
0.0272 mol H/0.00546 mol N = 4.98 mol H/1 mol N
0.0383 mol C/0.00546 mol N = 7.01 mol C/1 mol N
The empirical formula is $C_7H_5O_3SN$
Empirical formula mass = 183 g/mol
The molecular formula is $C_7H_5O_3SN$

7.112 (a) $4.31\ \cancel{\text{mol IF}_5} \times \dfrac{222\ \cancel{\text{g IF}_5}}{1\ \cancel{\text{mol IF}_5}} \times \dfrac{1\ \text{cm}^3\ \text{IF}_5}{3.252\ \cancel{\text{g IF}_5}} = 294\ \text{cm}^3\ \text{IF}_5$

(b) $2.65\ \cancel{\text{L IF}_5} \times \dfrac{1000\ \cancel{\text{cm}^3}}{1\ \cancel{\text{L}}} \times \dfrac{3.252\ \cancel{\text{g IF}_5}}{1\ \cancel{\text{cm}^3\ \text{IF}_5}} \times \dfrac{1\ \cancel{\text{mol IF}_5}}{222\ \cancel{\text{g IF}_5}} \times \dfrac{5\ \text{mol F}}{1\ \cancel{\text{mol IF}_5}} = 194\ \text{mol F}$

(c) $4.821 \times 10^{23}\ \cancel{\text{atoms F}} \times \dfrac{1\ \text{mol F}}{6.022 \times 10^{23}\ \cancel{\text{atoms F}}} \times \dfrac{1\ \cancel{\text{mol IF}_5}}{5\ \text{mol F}} \times \dfrac{222.0\ \cancel{\text{g IF}_5}}{1\ \cancel{\text{mol IF}_5}} \times \dfrac{1\ \text{cm}^3}{3.252\ \cancel{\text{g IF}_5}} = 10.93\ \text{cm}^3\ \text{IF}_5$

7.115 (a) $1\ \cancel{\text{lb 18 carat gold}} \times \dfrac{75\ \cancel{\text{lb}}\ 24\ \text{carat gold}}{100\ \cancel{\text{lb 18 carat gold}}} \times \dfrac{454\ \text{g}}{1\ \cancel{\text{lb}}}$
$= 3.4 \times 10^2\ \text{g 24 carat gold}$

(b) $3.4 \times 10^2\ \cancel{\text{g Au}} \times \dfrac{1\ \cancel{\text{mol Au}}}{197\ \cancel{\text{g Au}}} \times \dfrac{6.0 \times 10^{23}\ \text{atoms Au}}{1\ \cancel{\text{mol Au}}}$
$= 1.0 \times 10^{24}\ \text{atoms Au}$

7.116 $10.0\ \cancel{\text{cm}} \times \dfrac{1\ \cancel{\text{atom C}}}{1.5 \times 10^{-8}\ \cancel{\text{cm}}} \times \dfrac{1\ \cancel{\text{mol C}}}{6.022 \times 10^{23}\ \cancel{\text{atoms C}}} \times \dfrac{12.0\ \text{g C}}{1\ \cancel{\text{mol C}}}$
$= 1.3 \times 10^{-14}\ \text{g C}$

7.118 (a) (g H/g $C_7H_5N_3O_6$) × 100 = (5.04 g H/227 g $C_7H_5N_3O_6$) × 100 = 2.22% H

7.18 (b) $3.94\ \text{g TNT} \times \frac{1\ \text{mol TNT}}{227\ \text{g TNT}} \times \frac{7\ \text{mol C}}{1\ \text{mol TNT}} \times \frac{12.0\ \text{g C}}{1\ \text{mol C}} = 1.46\ \text{g C}$

$3.94\ \text{g TNT} \times \frac{1\ \text{mol TNT}}{227\ \text{g TNT}} \times \frac{5\ \text{mol H}}{1\ \text{mol TNT}} \times \frac{1.01\ \text{g H}}{1\ \text{mol H}} = 0.0874\ \text{g H}$

$3.94\ \text{g TNT} \times \frac{1\ \text{mol TNT}}{227\ \text{g TNT}} \times \frac{3\ \text{mol N}}{1\ \text{mol TNT}} \times \frac{14.0\ \text{g N}}{1\ \text{mol N}} = 0.729\ \text{g N}$

$3.94\ \text{g TNT} \times \frac{1\ \text{mol TNT}}{227\ \text{g TNT}} \times \frac{6\ \text{mol O}}{1\ \text{mol TNT}} \times \frac{16.0\ \text{g O}}{1\ \text{mol O}} = 1.66\ \text{g O}$

7.119 (a) From the formula XBr_2 you know there are two moles of Br and one mole of X in one mole of XBr_2. Use this information to determine the formula mass of XBr_2 and then the atomic mass of X

$$\frac{2\ \text{mol Br}}{1\ \text{mol } XBr_2} \times \frac{79.90\ \text{g Br}}{1\ \text{mol Br}} \times \frac{100\ \text{g } XBr_2}{71.55\ \text{g Br}} = \frac{223.3\ \text{g } XBr_2}{\text{mol } XBr_2}$$

100% – 71.55% Br = 28.45% X

$$\frac{1\ \text{mol } XBr_2}{1\ \text{mol X}} \times \frac{223.3\ \text{g } XBr_2}{1\ \text{mol } XBr_2} \times \frac{28.45\ \text{g X}}{100\ \text{g } XBr_2} = \frac{63.54\ \text{g X}}{\text{mol X}}$$

(b) The atomic mass of 63.54 corresponds to copper.

7.121 $$\frac{1\ \text{lb}}{1\ \text{mol}} \times \frac{453.6\ \text{g}}{1\ \text{lb}} \times \frac{6.022 \times 10^{23}\ \text{atoms}}{1\ \text{g/mol}} = 2.732 \times 10^{26}\ \text{atoms}$$

7.122 (a) $\frac{1}{2}(C_{10}H_{14}N_2) = C_5H_7N$

(b) $1.48\ \text{g cigarette} \times \frac{2.1\ \text{g nicotine}}{100\ \text{g cigarette}} \times \frac{1\ \text{mol nicotine}}{162\ \text{g nicotine}}$

$$\times \frac{6.0 \times 10^{23}\ \text{molecules nicotine}}{1\ \text{mol nicotine}} = 1.2 \times 10^{20}\ \text{molecules nicotine}$$

7.123 (a) $\frac{1\ \text{cm}^3\ \text{solution}}{1.67\ \text{g solution}} \times \frac{11.7\ \text{mol } HClO_4}{1000\ \text{cm}^3\ \text{solution}} \times \frac{100\ \text{g } HClO_4}{1\ \text{mol } HClO_4} = \frac{0.704\ \text{g } HClO_4}{1\ \text{g solution}}$

$= 70.4\%\ HClO_4$

(b) $\frac{255\ \text{mL solution}}{1} \times \frac{11.7\ \text{mol } HClO_4}{1000\ \text{mL solution}} = 2.98\ \text{mol } HClO_4$

$\frac{2.98\ \text{mol } HClO_4}{1} \times \frac{1000\ \text{mL solution}}{5.95\ \text{mol } HClO_4} = 501\ \text{mL solution}$

(c) $\frac{81.2\ \text{mL solution}}{1} \times \frac{11.7\ \text{mol } HClO_4}{1000\ \text{mL solution}} = 0.950\ \text{mol } HClO_4$

$\frac{0.959\ \text{mol } HClO_4}{10.6\ \text{L solution}} = 0.896\ \text{M } HClO_4$

CHAPTER EIGHT

MOLECULES, COMPOUNDS, AND CHEMICAL BONDING

8.37 (b) Magnesium oxide (c) Rubidium iodide (e) Strontium fluoride
(h) Gallium phosphide

8.40 (c) Dinitrogen tetroxide (e) Disulfur dichloride (h) Selium tetrabromide

8.41 (c) Dichlorine heptoxide (e) aluminum oxide (g) Ditellurium decafluoride
(h) Selenium hexafluoride

8.52 Electronegativity increases from left to right across a period and decreases down a group. Also, the closer an element is to fluorine on the periodic table, the higher its electronegativity generally is.
(b) Sn–most distant from fluorine
(c) Fr–farthest down the group
(d) Al–to the left of the other elements
(a) I (e) Te

8.53 (a) P is closest to the top of the group, so it will have the highest electronegativity. Sb is the farthest down the group, so it will have the lowest electronegativity. The order will be P > As > Sb
(b) B is to the right of the other elements so its electronegativity is the highest. Li is to the left so its is the lowest. The order will be B > Be > Li
(c) Sr > Ba > Rb > Cs

8.54 (a) Ca^{2+} has 18 (20 – 2) electrons which is the same as Ar.
(b) N^{3-} has 10 (7 + 3) electrons which is the same as Ne.
(d) Rb^{+} has 36 (37 – 1) electrons which is the same as Kr.
(g) P^{3-} has 18 (15 + 3)electrons which is the same as Ar.
(h) O^{2-} has 10 (8 + 2) electrons which is the same as Ne.
(c) Kr (e) Xe (f) Ne

8.55 (c) (d) (f) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$

8.56 Ionic radius increases down a group. The ionic radius of cations decreases from left to right across a period and the ionic radius of anions decreases across a period, but anions are larger than cations in the same period.
(a) Se^{2-} is father down the group so it will have a larger ionic radius.
(b) N^{3-} is to the left of the other anions so it will have a larger ionic radius.
(c) Na^{+} (d) K^{+}

8.57 (d) $Ca: + :\ddot{S}: \longrightarrow Ca^{2+} + [:\ddot{S}:]^{2-}$

(e) $Cs\cdot + :\ddot{P}\cdot + Cs\cdot + Cs\cdot \longrightarrow 3Cs^{+} + [:\ddot{P}:]^{3+}$

8.58 (c) $Sr^{2+}\ [:\ddot{O}:]^{2-}$ (f) $Al^{3+}\ [:\ddot{N}:]^{3-}$ (g) $2K^{+}\ [:\ddot{S}e:]^{2-}$

8.59 (a) To achieve the noble gas configuration Al will lose 3 electrons and oxygen will gain two electrons. In order to balance the electrons, two atoms of Al and three atoms of O are required. A total of six electrons will be transferred from Al to O, resulting in the formula Al_2O_3.

(b) Sr will lose two electrons and S will gain two electrons to achieve a noble gas configuration. The formula is SrS.

(c) Mg will lose two electrons and Br will gain one electron. Two Br atoms and one Mg atom are required in the formula unit $MgBr_2$.

(f) Li will lose one electron and Se will gain two electrons. Two Li atoms and one Se atom are required for the formula unit Li_2Se.

(b) Ga_2O_3 (e) NaF (g) AlF_3 (h) Ca_3P_2

8.63 Covalent bonds are always formed by the sharing of electrons in the outer sublevel of the atoms.

(a) In a hydrogen atom, the outermost electron resides in the ls orbital. In an iodine atom, the outermost electron resides in the 5p orbital.

(b) The outer electrons in I are in the 5p.
The outer electrons in Br are in the 4p.

(d) The outer electrons in N are in the 2p.
The outer electrons in Cl are in the 3p.

(g) The outer electrons in N are in the 2p.
The outer electrons in H are in the ls.

(c) 3p, 5p (e) 2p, 4p

8.64 (a) Cl is more electronegative than Br, so BrCl is polar.

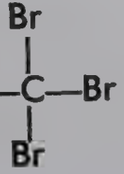
(b) Both oxygen atoms in O_2 will have the same electronegativity, so it will be nonpolar.

(d) O is more electronegative than N, so NO is polar.

(c) Polar (e) Nonpolar (f) Polar (g) Nonpolar

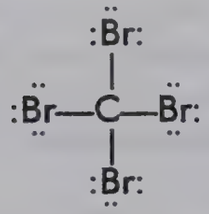
8.66 (a) 1. Total outer-level electrons = $4 \times 7(4F) + 1 \times 4(1C) = 32$.

2. The central atom is C:



8.66 (a) 3. Four bonds are formed. The remaining number of electrons = 32 – 8 = 24.

4. Each Br atom needs six more electrons to complete the octet. C has eight electrons, so a total of 24 electrons are required. This is the number available and only single bonds are formed.



5. Each Br atom has eight electrons and the C atom has eight electrons. Thirty-two electrons are counted in the Lewis structure, which corresponds to the total number of outer-level electrons in four Br atoms and one C atom.

(b) 1. Total outer-level electrons = 1 × 6(1O) + 2 × 7(2F) = 20.

2. The central atom is O: F—O—F

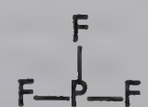
3. 2 bonds are formed. The remaining number of electrons = 20 – 4 = 16.

4. Each F atom needs six electrons and the O atom needs four electrons. A total of 16 electrons are needed which is the number available. Only single bonds are present.



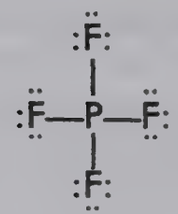
5. Each F atom has eight electrons and the O atom has eight electrons. A total of 20 electrons are counted in the Lewis structure, which corresponds to the total number of outer-level electrons in two F atoms and one O atom.

(d) 1. Total outer-level electrons = 1 × 5(1P) + 3 × 7(3F) = 26.

2. The central atom is P: 

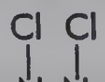
3. Three bonds are formed. The remaining number of electrons = 26 – 6 = 20.

4. Each F atom needs six electrons and the P atom needs two electrons for a total of 20 electrons, which corresponds to the number of electrons available. Only single bonds are present.



8.66 (d) 5. Each F atom has eight electrons and the P atom has eight electrons. A total of 26 electrons are counted in the Lewis structure, which corresponds to the total number of outer-level electrons in three F atoms and one P atom.

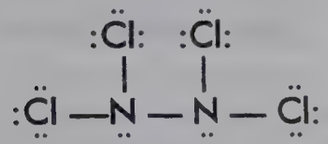
(f) 1. Total outer-level electrons = $2 \times 5(2N) + 4 \times 7(4Cl) = 38$.



2. The central atoms are N: Cl–N–N–Cl

3. 5 bonds are formed. The remaining number of electrons = 38 – 10 = 28.

4. Each Cl atom needs six electrons and each N atom needs two electrons for a total of 28 electrons, which corresponds to the number of electrons available. Only single bonds are present.



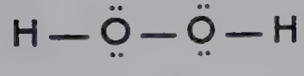
5. Each Cl atom has eight electrons and each P atom has eight electrons. A total of 48 electrons are counted in the Lewis structure, which corresponds to the total number of outer-level electrons in four Cl atoms and two N atoms.

(i) 1. Total outer-level electrons = $2 \times 1(2H) + 2 \times 6(2O) = 14$.

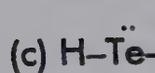
2. The central atom is O: H—O—O—H

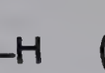
3. 3 bonds are formed. The remaining number of electrons = 14 – 6 = 8.

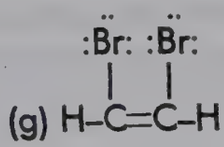
4. Each H atom has the maximum of two electrons. Each O atom needs four electrons, which corresponds to the number of electrons available. Only single bonds are present.

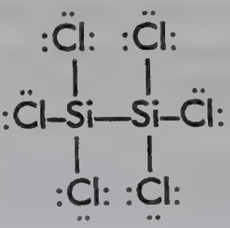


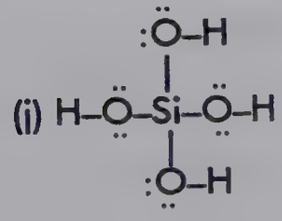
5. Each H atom has two electrons and each O atom has eight electrons in the Lewis structure, which corresponds to the total number of outer-level electrons in two H atoms and two O atoms.

(c) 

(e) 

(g) 

(h) 

(i) 

8.67 (a) 1. $1 \times 6(1O) + 1 \times 1(1H) + 1(1-\text{ charge}) = 8$ outer-level electrons.

2. O—H

3. $8 - 2 = 6$ electrons remain.

4. 6 electrons are required for the O atom.



5. 8 electrons in the Lewis structure correspond to the total number of outer-level electrons in one O atom and one H atom with a net 1– charge.

(b) 1. $1 \times 4(1C) + 1 \times 5(1N) + 1(1-\text{ charge}) = 10$ outer-level electrons.

2. C—N

3. $10 - 2 = 8$ electrons remain.

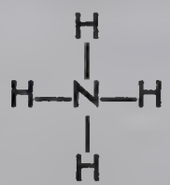
4. The C atom and the N atom both require six more electrons for a total of 12 electrons. A triple bond is required.



5. 10 electrons in the Lewis structure correspond to the total number of outer-level electrons in one C atom and one N atom with a net 1– charge.

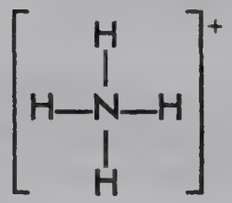
(c) 1. $1 \times 5(1N) + 4 \times 1(4H) - 1(1+\text{ charge}) = 8$ outer-level electrons.

2.



3. $8 - 8 = 0$ electrons remain.

4. The four H atoms each have the required 2 electrons and the N atom has eight electrons.



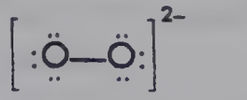
5. 8 electrons in the Lewis structure correspond to the total number of outer-level electrons in one N atom and four H atoms with a net 1+ charge.

(f) 1. $2 \times 6(2O) + 2(2-\text{ charge}) = 14$ outer-level electrons.

2. O—O

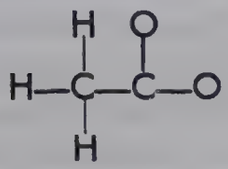
3. $14 - 2 = 12$ electrons remain.

8.67 (f) 4. Each of the O atoms needs 6 more electrons for a total of 12 electrons.

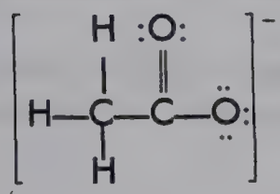


5. 14 electrons in the Lewis structure correspond to the total number of outer-level electrons in two O atoms with a net 2– charge.

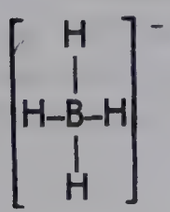
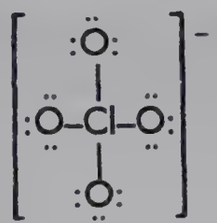
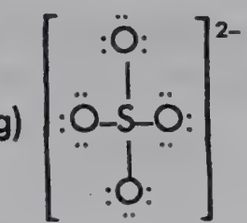
(h) 1. $2 \times 4(2C) + 3 \times 1(3H) + 2 \times 6(2\ O) + 1(1-\text{ charge}) = 24$ outer-level electrons.

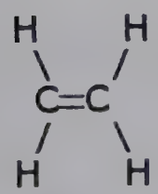
2. 

3. 24 – 12 = 12 electrons remain.
4. The C atom needs 2 more electrons and each O atom needs 6 more electrons for a total of 14 electrons required. Since only 12 are available, a double bond must be formed.

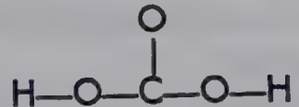


5. 24 electrons in the Lewis structure correspond to the total number of outer-level electrons in 3 H atoms, 2 C atoms, and 2 O atoms with a net 1– charge.

(d)  (e)  (g) 

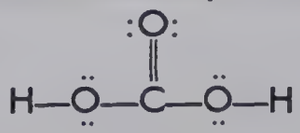
8.68 (b)  (c) H–C≡C–H

8.69 (a) 1. $3 \times 6(3O) + 1 \times 4(1C) + 2 \times 1(2H) = 24$ outer-level electrons.

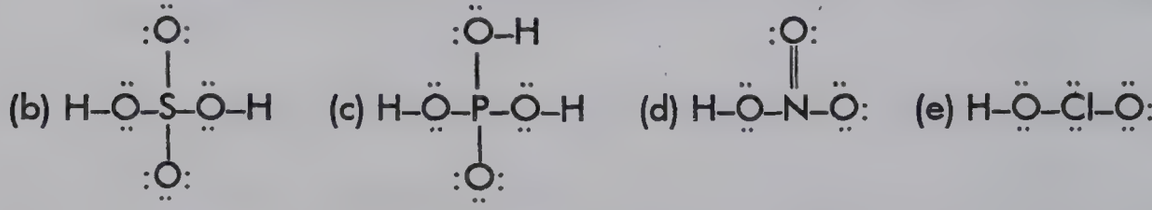
2. 

3. 24 – 10 = 14 electrons remain.
4. The two H atoms each have the required two electrons, the C atom needs two more electrons, two O atoms need four more electrons, and one O atom needs six electrons for a total of 16 electrons required.

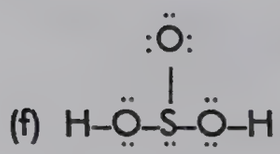
8.69 (a) 4. Because only 14 are available, a double bond must be present.



5. 24 electrons in the Lewis structure correspond to the total number of outer-level electrons in 2 H atoms, 1 C atom, and 3 O atoms. Use the same procedure as in (a) to obtain the Lewis structures shown below for (b) - (f).



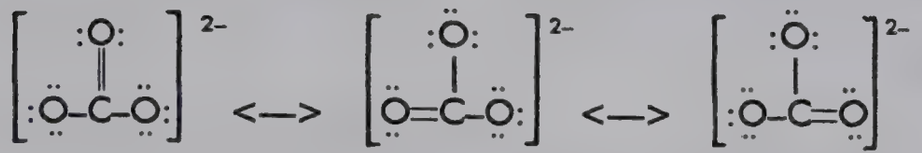
(b) (c) (d) (e)



(f)

8.71 (b) The P atom in PF_5 contains 10 outer-level electrons.
(e) The S atom in SF_6 contains 12 outer-level electrons.
(c) IF_5

8.72 (b)



(c)



(d)



(e)



8.74 (a) The Lewis structure of NF_3 contains three single bonds between the N atom and the F atoms and one lone pair of electrons on the central N atom. This arrangement results in trigonal pyramidal geometry.
(b) The Lewis structure of H_2S contains two single bonds between the central S atom and the H atoms and two lone pairs of electrons on the S atom. This arrangement results in angular geometry.
(c) The Lewis structure of SiF_4 contains four single bonds between the central Si atom and the F atoms. The resulting structure has tetrahedral geometry.

8.74 (e) BeF_2 is electron deficient. The Lewis structure contains only two single bonds between the central Be atom and the F atoms. The molecule has linear geometry.

(g) The Lewis structure of HCN contains a single bond between the H atom and the central C atom and a triple bond between the C atom and the N atom. The molecule has linear geometry.

(d) Trigonal planar (f) Trigonal planar (h) Pyramidal

8.75 (a) The Lewis structure of NO_2^- contains one single bond and one double bond between the central N atom and the O atoms. There is one lone pair of electrons on the N atom resulting in an angular geometry.

(c) The Lewis structure of CO_3^{2-} contains two single bonds and one double bond between the central C atom and the O atoms. The resulting structure has trigonal planar geometry.

(e) The Lewis structure of SO_4^{2-} contains four single bonds between the central S atom and the atoms. The molecule has tetrahedral geometry.

(b) Trigonal planar (d) Linear (f) Trigonal planar

8.77 (a) A triple bond gives a bond order of three.

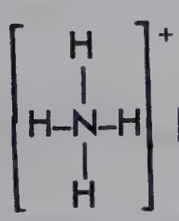
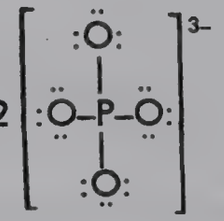
(b) A single bond gives a bond order of one.

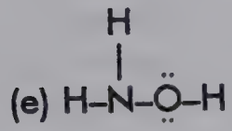
(c) 1 (d) 1

8.79 (b) ... and its *bonding* electrons. (d) *Covalent* ... (f) ... *formula units* ...

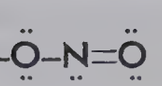
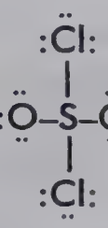
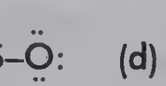
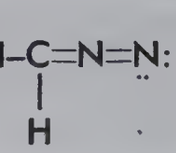
(h) ... atoms, or *atoms with the same electronegativity* ...

8.82 (c) No. The double bond is localized between the carbon atom and the oxygen atom. It cannot be placed between any other atoms without rearranging the atoms.

8.83 (b)  (c) $Ca^{2+}\ 2[:\ddot{Cl}-\ddot{O}:]^-$ (d) $3Mg^{2+}\ 2$ 

(e) 

bond order of two and C–C has a bond order on one.

8.88 (b)  (c)  (d)  (e) 

CHAPTER NINE

CHEMICAL NOMENCLATURE

For exercises 9.31, 9.32, 9.34, and 9.51 the symbol for the element is used to represent the oxidation number of that element in the equation. The equation is then solved to obtain the variable oxidation number of the element in the compound.

9.31 (a) F_2 is a pure element so the oxidation number is 0.
(c) Mg in group IIA is +2. S in group VIA is –2.
(e) O is –2. 2N + 5O = 0, 2N + 5(–2) = 0, N = +5
(g) Al in group IIIA is +3. S in group VIA is –2.
(b) H +1, O –2 (d) N +3, Cl –1 (f) P +5, Cl –1 (h) C +4, I –1

9.32 (a) S + 3 O = 0, S + 3(–2) = 0, S = +6
(d) 2H + S + 3 O = 0, 2(+l) + S + 3(–2) = 0, S = +4
(g) 2S + 3 O = 0, 2S + 3(–2) = 0, S = +3
(b) +4 (c) +6 (e) 0 (f) +6 (h) +5

9.34 (a) 2K + 2Cr + 7 O = 0, 2(+l) + 2Cr + 7(–2) = 0, Cr = +6
(c) 2Na + U + 4 O = 0, 2(+l) + U +4(–2) = 0, U = +6
(e) Ca + 2H + 2S = 0, +2 + 2(+1) +2S = 0, S = –2
(g) 4K + 2V + 7 O = 0, 4(+l) + 2V + 7(–2) = 0, V = +5
(i) Cu + 2C + 2N = 0, +2 + 2C + 2(–3) = 0, C = +2
(b) Na +1, Ge +4, O –2 (d) Rb +1, H +1, S +6, O –2
(f) 2U +6 and 1U+4, O –2 (h) Na +1, C +3, O –2 (i) Na +1, O –1
(k) Mg +2, H –1

9.36 (e) Oxygen difluoride (f) Silicon dioxide (g) Xenon tetroxide
(h) Iodine heptafluoride

9.37 (a) Bromine, a halogen, will have an oxidation number of –1. The oxidation number of tin must then be +2, tin(II). Tin(II) bromide.
(b) Nitrogen, in group V, has an oxidation number of –3 in binary compounds. The oxidation number of cobalt must be +3, cobalt(III). Cobalt(III) nitride.
(c) Sulfur, in group VI, has an oxidation number of –2 in binary compounds. The oxidation number of lead must be +2, lead(II). Lead(II) sulfide.
(d) Phosphorus, in group V, has an oxidation number of –3 in binary compounds. The oxidation number of copper must be +1, copper(I). Copper(I) phosphide.

9.37 (e) Oxygen has an oxidation number of –2 in binary compounds. The oxidation number of mercury must be +2, mercury(II). Mercury(II) oxide.
(f) Sodium selenide (g) Magnesium chloride (h) Scandium(III) oxide
(i) Cadmium(II) iodide

9.38 (a) Iron(III) is Fe^{3+} and bromide is Br^-, so 3 Br ions are required; $FeBr_3$.
(e) Magnesium is Mg^{2+} and oxygen is O^{2-}; MgO.
(h) The oxidation number of tin(II) is +2 and that of nitrogen is –3. The lowest common multiple of +2 and –3 is 6. Three Sn atoms and two N atoms are required resulting in the formula Sn_3N_2.
(j) Rubidium is Rb^+ and Phosphide is P^{3-}. Three Rb ions are required; Rb_3P.
(b) MnS (c) CuI (d) CrF_2 (f) BaC_2 (g) Hg_2F_2 (i) PbSe

9.39 (a) The oxidation number of thallium(III) is +3 and that of oxygen is –2. The lowest common multiple of +3 and –2 is 6. Two Tl atoms and three O atoms are required; Tl_2O_3.
(b) The oxidation number of uranium(IV) is +4 and that of oxygen is –2. Two O atoms are required; UO_2.
(c) The oxidation number of gold(I) is +1 and that of oxiyge is –2. Two Au atoms are required; Au_2O.
(d) The oxidation number of molybdium(V) is +5 and that of oxygen is –2. The lowest common multiple of +5 and –2 is 10. Two Mo atoms and five O atoms are required; Mo_2O_5.
(e) The oxidation number of manganese(VII) is +7 and that of oxygen is –2. The lowest common multiple of +7 and –2 is 14. Two Mn atoms and seven O atoms are required; Mn_2O_7.
(f) RuO_2 (g) W_2O_7 (h) VO_2 (i) Sc_2O_3 (j) SnO_2

9.40 Iron(II) acetate, phosphate, permanganate, cyanide, carbonate, hydroxide, sulfide; mercury(II) acetate, phosphate, permanganate, cyanide, carbonate, hydroxide, sulfide; tin(IV) acetate, phosphate, permanganate, cyanide, carbonate, hydroxide, sulfide; rubidium acetate, phosphate, permanganate, cyanide, carbonate, hydroxide, sulfide; gold(III) acetate, phosphate, permanganate, cyanide, carbonate, hydroxide, sulfide.

9.41 The cations are: Ca^{2+}, Al^{3+}, and Pb^{4+}. The anions are OH^-, $C_2H_3O_2^-$, SO_4^{2-}, ClO_3^-, SeO_4^{2-} and N^{3-}. When subscripts are used that result in equal numbers of positive and negative charges the formulas given in Appendix D are obtained.
$Co(OH)_2$, $Co(C_2H_3O_2)_2$, $CoSO_4$, $Co(ClO_3)_2$, $CoSeO_4$, Co_3N_3
NH_4OH, $NH_4C_2H_3O_2$, $(NH_4)_2SO_4$, NH_4ClO_3, $(NH_4)_2SeO_4$, $(NH_4)_3N$
$Ge(OH)_4$, $Ge(C_2H_3O_2)_4$, $Ge(SO_4)_2$, $Ge(ClO_3)_4$, $Ge(SeO_4)_2$, Ge_3N_4
$Sn(OH)_2$, $Sn(C_2H_3O_2)_2$, $SnSO_4$, $Sn(ClO_3)_2$, $SnSeO_4$, Sn_3N_2

9.42 $Al_2(SO_4)_3$, calcium carbonate, $NaHCO_3$, copper(II) sulfate pentahydrate, $SrSO_4$, lead(II) chromate, $Au(CN)_3$, sodium sulfate, Zn_2SiO_4, barium nitrate

9.44 Acetate is $C_2H_3O_2^-$.
(a) Li^+ requires one $C_2H_3O_2^-$, $LiC_2H_3O_2$.
(b) Zn^{2+} requires two $C_2H_3O_2^-$, $ZnC_2H_3O_2)_2$.
(e) Ga^{3+} requires three $C_2H_3O_2^-$, $Ga(C_2H_3O_2)_3$.
(c) $Fe(C_2H_3O_2)_2$ (d) $Cu(C_2H_3O_2)_2$ (f) $Tl(C_2H_3O_2)_3$ (g) $Pb(C_2H_3O_2)_4$
(h) $Ir(C_2H_3O_2)_4$

9.45 (c) Hydroselenic acid (d) Hydrosulfuric acid

9.46 (a) BO_3^{3-} is borate, so the oxyacid is named boric *acid*.
(b) ClO^- has two less O atoms than chlorate, ClO_3^- ; therefore, it would be named *hypochlorite*. The oxyacid is named *hypochlorous acid*.
(c) IO_3^- is iodate, so the oxyacid is iodic acid.
(d) AsO_4^{3-} is arsenate, so the oxyacid is named arsenic acid.
(e) CO_3^{2-} is carbonate, so the oxyacid is carbonic acid.
(f) BrO_4^- has one more O atom than bromate, BrO_3^- ; therefore, it would be named perbromate. The oxyacid is named perbromic acid.

9.48 (a) IO_4^- has one more O atom than iodate, IO_3^-; therefore, it would be named periodate. The oxyacid is named periodic acid.
(b) $C_2H_3O_2^-$ is the acetate ion. The acid is named acetic acid.
(e) CN^- is the cyanide ion. The acid is named cyanic acid.
(c) Selenous acid (d) Hypoiodous acid

9.50 (a) SO_3^{2-} has one less O atom than sulfate, SO_4^{2-}; therefore, it is named sulf*ite*. The hydrogen atom produces the name hydrogensulf*ite*. The acid, H_2SO_3, from which it is derived is sulfur*ous* acid.
(b) PO_3^{3-} has one less O atom than phosphate, PO_4^{3-} ; therefore, it is named phosph*ite*. One hydrogen is denoted as *monohydrogen*phosph*ite*. The acid, H_3PO_3, from which it is derived is phosphor*ous* acid.
(c) Hydrogensulfate, sulfuric acid (d) Hydrogencarbonate, carbonic acid

9.51 (a) Na and H are in group IA. Their oxidation state is +1. F is in group VIIA so it is –1.
(b) Na and H in group IA are +1, O in group VIA is –2. S is found by; 2Na + 2S + 6 O = 0, 2(+l) + 2S + 6(–2) = 0, S = +5.
(c) Na in group IA is +1, F in group VIIA is –1, B in group IIIA is +3.
(d) Na +1, Mo +6, O –2 (e) Na +1, Si +4, F –1 (f) Na +1, As +5, S –2

9.55 (a) Since the anion, phosphate, has a charge of 3– chromium must have an oxidation state of +3. Six water molecules are denoted by hexahydrate so the name is chromium(III) phosphate hexahydrate.
(b) Gallium must have an oxidation state of +3 so that the two Ga atoms will balance the three O atoms, each of which has an oxidation state of –2. One water molecule is denoted as monohydrate. The name is gallium(III) oxide monohydrate.
(c) Indium must have an oxidation state of +3 to balance the three ClO_4^- ions. ClO_4^- with one more O atom than chlorate is named *perchlorate*. Eight water molecules are denoted as octahydrate resulting in the name indium(III) perchlorate octahydrate.
(d) Iron(III) phosphate dihydrate (e) Lithium iodide trihydrate
(f) Sodium carbonate decahydrate

9.56 (a) Na has a charge of 1+, borate is BO_3^{3-}, and tetrahydrate is $4H_2O$. The result is $Na_3BO_3 \cdot 4H_2O$.
(d) Mercury(II) has an oxidation number of +2, bromate is BrO_3^-, and dihydrate is $2H_2O$. The formula is $Hg(BrO_3)_2 \cdot 2H_2O$.
(b) $Th(SeO_4)_2 \cdot 9H_2O$ (c) $Ni_3(PO_4)_2 \cdot 8H_2O$ (e) $Mn(C_2H_3O_2)_2 \cdot 4H_2O$
(f) $Pb(BrO_4)_2 \cdot H_2O$

9.57 (26) Iron(III) dihydrogenhypophosphite (27) Lead(IV) hypoarsenite
(28) Lithium chlorate (29) Magnesium nitrate (30) Manganese(III) arsenide
(31) Mercury(II) bromate (32) Molybdenum(VI) sulfite (33) Trisilicon octachloride (34) Osmium(II) oxide (35) Lead(II) nitrate (36) Phosphorus pentabromide (37) Platinum(II) hydroxide (38) Potassium dihydrogenarsenate (39) Radium carbonate (40) Rhenium(VI) fluoride
(41) Rhodium(III) sulfate (42) Rubidium selenate (43) Scandium(III) oxide
(44) Selenium(IV) fluoride (45) Silver(I) tellurite (46) Sodium dihydrogenphosphite (47) Strontium permanganate (48) Disulfur difluoride (49) Thallium(I) cyanide (50) Tin(IV) sulfate

9.58 (26) KIO_3 (27) $ReCl_6$ (28) $Sn_3(PO_4)_4$ (29) $RbClO_2$ (30) $Sc_2(SO_4)_3$ (31) Si_3N_4
(32) H_2SiO_3 (33) Ag_3PO_4 (34) $NaHSO_3$ (35) $Sr(IO_3)_2$ (36) TaN (37) Tl_2SO_4
(38) SnI_4 (39) $Zn(CN)_2$ (40) $Co_3(PO_4)_2$ (41) NH_4BrO_2 (42) AlN (43) CaC_2
(44) HClO (45) $Fe(C_2H_3O_2)_3$ (46) $MnCO_3$ (47) HgS (48) HCN(aq)
(49) $KMnO_4$ (50) $Ce_2(CO_3)_2$

9.60 (a) 100.0% – 25.5% H_2O = 74.5% $Mg_3(PO_4)_2$

$$74.5 \text{ g } \cancel{Mg_3(PO_4)_2} \times \frac{1 \text{ mol } Mg_3(PO_4)_2}{263 \text{ g } \cancel{Mg_3(PO_4)_2}} = 0.283 \text{ mol } Mg_3(PO_4)_2$$

$$25.5 \text{ g } H_2O \times 1 \text{ mol } H_2O/18.0 \text{ g } H_2O = 1.42 \text{ mol } H_2O$$

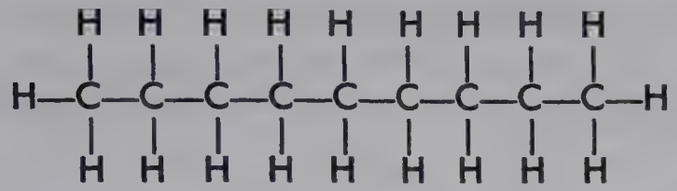
9.60 (a) 0.283 ~~mol $Mg_3(PO_4)_2$~~/0.283 ~~mol $Mg_3(PO_4)_2$~~ = 1.00

1.42 mol H_2O/0.283 mol $Mg_3(PO_4)_2$ = 5.01 mol H_2O/1 mol $Mg_3(PO_4)_2$.
The empirical formula is $Mg_3(PO_4)_2 \cdot 5H_2O$. The empirical formula mass is 353 g/mol. The formula is $Mg_3(PO_4)_2 \cdot 5H_2O$

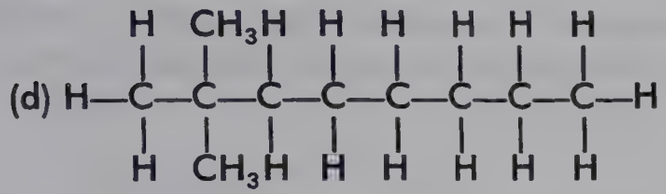
(b) Magnesium phosphate pentahydrate

9.62 %W = (g W/g WBr_6) × 100 = (184 g W/663 g WBr_6) × 100 = 27.7% W
%Br = 100.0 – %W = 100.0 – 27.7 = 72.3% Br

9.67 (b)

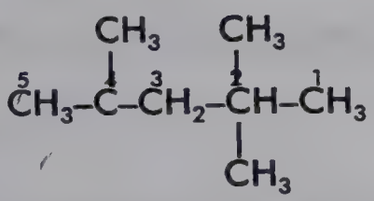


(d)



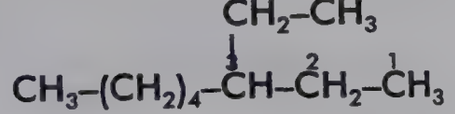
9.68 (b) Nonane (d) Decane

9.69 (a)



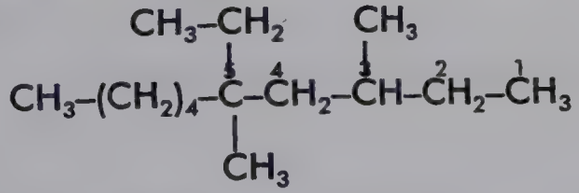
The longest chain is 5 C atoms, making it a pentane. There are 3 branched CH_3, methyl groups, two on carbon 2, and one on carbon 4.
2,2,4-trimethylpentane

(c)



The longest chain is 8 C atoms, making it an octane. A CH_2CH_3, ethyl group, is branched from the third carbon. 3-ethyloctane

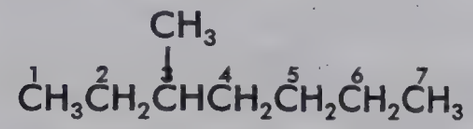
(e)



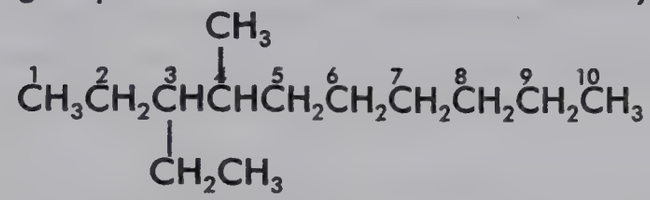
The longest chain is 10 C atoms, making it a decane. There are 2 branched CH_3, methyl groups, – one on carbon 3 and one on carbon 5. There is one branched ethyl group on carbon 5. 3,5-dimethyl-5-ethyldecane

9.69 (b) 2,2,8-Trimethylnonane (d) 2,3,4,5-Tetramethylhexane
(f) 2,2,3,3-Tetramethylheptane

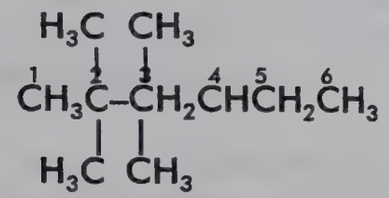
9.70 (a) 3-Methylheptane will consist of a seven carbon chain with a methyl group on the third carbon.



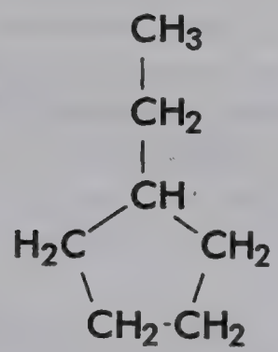
(c) 3-Ethyl-4-methyldecane will consist of a ten carbon chain with an ethyl group on the third carbon and a methyl group on the fourth carbon.



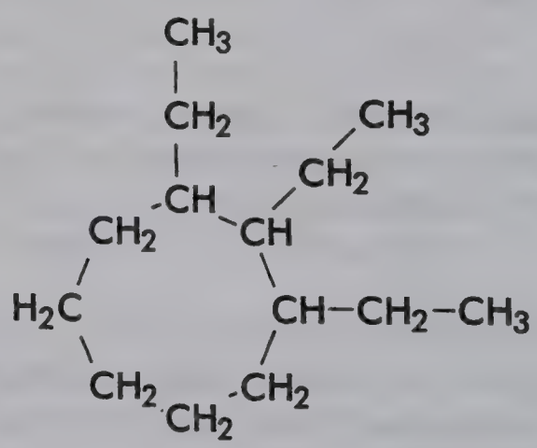
(e) 2,2,3,3-tetamethylhexane will consist of a six carbon chain with two methyl groups on the second carbon and two methyl groups on the third carbon atom.



(b) $CH_3C(CH_3)_2CH_2CH_2CH_3$ (d) $CH_3C(CH_3)_2CH_2CH(CH_3)CH_2CH_2CH_2CH_3$
(f) $CH_3CH_2CH_2CH(CH_2CH_3)CH_2CH_2CH_2CH_2CH_3$
(g)



(h)

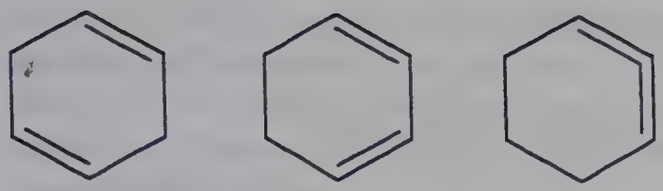


9.75 (b)



(c) $CH_3CH{=}CHCH_2CH_3$, $CH_2{=}CHCH_2CHCH_3$

9.75 (e)

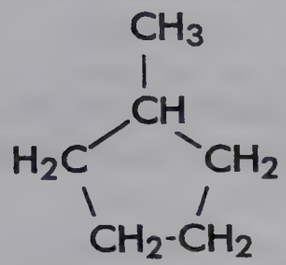


9.76 (a) 2-Methylbutane will consist of a four member carbon chain with a methyl group attached to the second carbon. $CH_3CHCH_2CH_3$ There are 12 H atoms.

CH_3

(b) $CH_3(CH_2)_6CH{=}CH_2$ There are 18 H atoms.

(c) Methylcyclopentane will consist of a five-member carbon ring with a methyl group bonded to it. There are 12 H atoms.

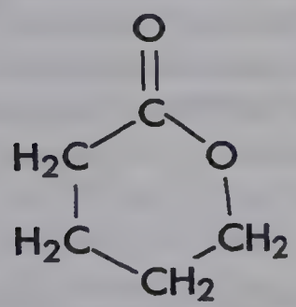


(d) Butyne is a four carbon chain containing a triple bond.
$CH_3C{\equiv}CCH_3$
There are 6 hydrogen atoms.

9.82 (d) –S– (e) –COOR'

9.84 (d) $CH_3CH_2CH_2CH_2COCH_3$ (e) $CH_3(CH_2)_6CH_2NH_3$

(f)



CHAPTER TEN

CHEMICAL REACTIONS

10.21 (c) One mole of nitrogen gas and three moles of hydrogen gas produce two moles of ammonia gas.

(d) One mole of solid aluminum sulfide and six moles of liquid water produce two moles of solid aluminum hydroxide and three moles of hydro-sulfuric acid.

10.22 (a) Balance the phosphorus atoms by placing a 2 as the coefficient of P_2O_5. This gives 4 P atoms on each side of the equation. Balance the oxygen atoms by placing a 5 as the coefficient of O_2. This gives 10 O atoms on both sides of the equation.

$P_4 + 5O_2 \longrightarrow 2P_2O_5$

(c) Balance the lithium atoms by placing a 2 as the coefficient of LiOH. This gives 2 Li atoms on both sides of the equation. It also gives 2 O atoms and 2 H atoms on both sides of the equation.

$Li_2O + H_2O \longrightarrow 2LiOH$

(d) Balance the chlorine atoms by placing a 2 as the coefficient of KCl. This gives 2 Cl atoms on both sides of the equation. Balance the potassium atoms by placing a 2 as the coefficient of KI. This gives 2 K atoms and also 2 I atoms on both sides of the equation.

$Cl_2 + 2KI \longrightarrow I_2 + 2KCl$

(f) There are 3 O atoms, 1 Fe atom, and 1 Si atom on both sides of the equation. The equation is balanced.

$FeO + SiO_2 \longrightarrow FeSiO_3$

(g) Ballance the oxygen atoms by placing a 3 as the coefficient of CO. This gives 3 O atoms on both sides of the equation. Balance the carbon atoms by placing a 2 as the coefficient of C and the sodium atoms by placing a 2 as the coefficient of Na. This gives 3 C atoms and 2 Na atoms on both sides of the equation.

$Na_2CO_3 + 2C \longrightarrow 2Na + 3CO$

(b) 3, 1, 1 (e) 2, 1, 2 (h) 1, 3, 1, 3 (i) 1, 3, 2 (j) 2, 3, 2, 2

10.23 (a) Balance the C atoms by placing a 4 as the coefficient of CO_2. This gives 4 C atoms on each side of the equation. Balance the H atoms by placing a 5 as the coefficient of H_2O. This gives 10 H atoms on both sides of the equation. There are now 13 O atoms on the products side and 2 O atoms on the reactants side. The coefficient 13/2 for O_2 will balance the equation. Multiplication of each coefficient by 2 gives:

$2C_4H_{10} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$.

10.23 (b) Balance the F atoms by placing a 3 as the coefficient of HF. This gives 3 F atoms on both sides of the equation. Balance the H atoms by placing a 3 as the coefficient of H_2O. This gives 6 H atoms on both sides of the equation. There is now 1 P atom and 4 O atoms on both sides of the balanced equation.

$POF_3 + 3H_2O \longrightarrow H_3PO_4 + 3HF$

(c) Balance the N atoms by placing a 2 as the coefficient of NO_2. This gives 2 N atoms on both sides of the equation. There is 1 Cu atom on both sides of the equation, but there are 6 O atoms on the reactants side and 7 O atoms on the products side. A coefficient of ½ for O_2 will balance the equation. Multiplication of the coefficients by 2 gives:

$2Cu(NO_3)_2 \longrightarrow 2CuO + 4NO_2 + O_2$.

(d) Balance the Ca atoms by placing a 3 as the coefficient of $CaCO_3$. This gives 3 Ca atoms on both sides of the equation. Balance the PO_4^{3-} ions by placing a 2 as the coefficient of H_3PO_4. This gives 2 PO_4^{3-} ions on both sides of the equation. Balance the C atoms by placing a 3 as the coefficient of CO_2. This gives 3 C atoms on both sides of the equation. A coefficient of 3 for H_2O will give 6 H atoms on both sides of the equation.

$3CaCO_3 + 2H_3PO_4 \longrightarrow Ca_3(PO_4)_2 + 3CO_2 + 3H_2O$

(e) Balance the S atoms by placing a 2 as the coefficient of SO_2. This gives 2 S atoms on both sides of the equation. There is 1 Fe atom on each side of the equation. Balance the O atoms by placing a 5/2 as the coefficient of O_2. This gives 5 O atoms on both sides of the equation. Multiplication of the coefficients by 2 gives:

$2FeS_2 + 5O_2 \longrightarrow 2FeO + 4SO_2$.

(f) 2, 3, 1, 3 (g) 4, 1, 1, 3 (h) 1, 3, 2, 3 (i) 1, 1, 1, 4 (j) 2, 31, 20, 22

10.24 (a) Balance the B atoms by placing a 2 as the coefficient of $B_3N_3H_6$ and a 3 as the coeffidient of B_2O_3. This gives 6 B atoms on both sides of the equation. Balance the N atoms by placing a 3 as the coefficient of N_2O_5. This gives 6 N atoms on both sides of the equation. Balance the H atoms by placing a 6 as the coefficient of H_2O . This gives 12 H atoms on both sides of the equation. There are now 30 O atoms on the products side, so a coefficient of 15 for O_2 will balance the equation.

$2B_3N_3H_6 + 15O_2 \longrightarrow 3N_2O_3 + 3B_2O_3 + 6H_2O$

(b) Balance the I atoms by placing a 3 as the coefficient of IBr. This gives 3 I atoms on both sides of the equation. Balance the Br atoms by placing a 3 as the coefficient of NH_4Br. This gives 3 Br atoms on both sides of the equation. Balance the N atoms by placing a 4 as the coefficient of NH_3. This gives 4 N atoms on both sides of the equation. There are 12 H atoms on both sides of the equation.

$3IBr + 4NH_3 \longrightarrow 3NH_3Br + NI_3$

10.24 (c) Balance the K atoms by placing a 2 as the coefficient of $KAlSi_3O_8$. This gives 2 K atoms on both sides of the equation. Balance the Si atoms by placing a 4 as the coefficient of SiO_2. This gives 6 Si atoms on both sides of the equation. Balance the H atoms by placing a 2 as the coefficient of H_2O. This gives 4 H atoms on both sides of the equation. There are 2 Al atoms and 20 O atoms on both sides of the balanced equation.

$2KAlSi_3O_8 + 2H_2O + CO_2 \longrightarrow K_2CO_3 + Al_2Si_2O_5(OH)_4 + 4SiO_2$

(d) Notice that oxygen appears in only two compounds in this equation. There are 4 O atoms on the reactants side and 3 O atoms on the products side. The lowest multiple is 12. Place a 3 as the coefficient of Co_3O_4, and a 4 as the coefficient of $A1_2O_3$. Balance the Co atoms by placing a 9 as the coefficient of Co. This gives 9 Co atoms on both sides of the equation. Balance the Al atoms by placing an 8 as the coefficient of Al. This gives 8 Al atoms on both sides of the equation.

$3Co_3O_4 + 8A1 \longrightarrow 9Co + 4A1_2O_3$

(e) There is 1 Al atom and 1 Na atom on both sides of the equation. Balance the H atoms by placing a 2 as the coefficient of H_2O. This gives 2 H atoms on both sides of the equation. There are 4 O atoms on both sides of the equation.

$Al(OH)_3 + NaOH \longrightarrow NaAlO_2 + 2H_2O$

(f) Balance the C atoms by placing a 7 as the coefficient of CO_2. This gives 7 C atoms on both sides of the equation. Balance the H atoms by placing a 3 as the coefficient of H_2O. This gives 6 H atoms on both sides of the equation. Balance the O atoms by placing 15/2 as the coefficient of O_2. This gives 17 O atoms on both sides of the equation. Multiply the coefficients by 2 to obtain the balanced equation:

$2C_7H_7O_2 + 15O_2 \longrightarrow 14CO_2 + 6H_2O$.

(k) Balance the K atoms by placing a 2 as the coefficient of K_2SO_4. Balance the C atoms and N atoms by placing a 6 as the coefficient of CO and a 3 as the coefficient of $(NH_4)_2SO_4$. This gives 4 K atoms, one Fe atom, 6 C atoms, and 6 N atoms on both sides of the equation. Balance the S atoms by placing a 6 as the coefficient of H_2SO_4. This gives 6 S atoms on both sides of the equation. Balance the H atoms and O atoms by placing a 6 as the coefficient of H_2O. This gives 24 H atoms and 30 O atoms on both sides of the equation.

$K_4Fe(CN)_6 + 6H_2SO_4 + 6H_2O \longrightarrow 2K_2SO_4 + FeSO_4 + 3(NH_4)_2SO_4 + 6CO$

(g) 12, 1, 4, 6 (h) 2, 2, 2, 1, 4 (i) 1, 5, 1, 2, 3 (j) 1, 2, 1, 2

(l) 4, 16, 6, 3, 4, 12

10.25 (k) $Hg_2(NO_3)_2(aq) + 2KCl(aq) \longrightarrow Hg_2Cl_2(s) + 2KNO_3(aq)$

(l) $CaSO_4 \cdot 2H_2O \xrightarrow{\Delta} CaSO_4 + 2H_2O$

(m) $(NH_4)_2S(aq) + CdCl_2(aq) \longrightarrow CdS(s) + 2NH_4Cl(aq)$

(n) $H_3PO_3 + 3NaOH(aq) \longrightarrow Na_3PO_3(aq) + 3H_2O$

10.25 (o) $2NH_3(g) + H_2SO_4 \longrightarrow (NH_4)_2SO_4(aq)$
(p) $CS_2(l) + 3Cl_2(g) \longrightarrow S_2Cl_2 + CCl_4$
(q) $Ca_3(PO_4)_2(aq) + 3H_2SO_4 \longrightarrow 2H_3PO_4 + 3CaSO_4$
(r) $2NH_3(aq) + 3Cu_2O \longrightarrow N_2(g) + 3H_2O + 6Cu(s)$
(s) $NH_4NO_3(s) \xrightarrow{\Delta} 2H_2O + N_2O(g)$
(t) $Mg(OH)_2(aq) + Zn(NO_3)_2(aq) \longrightarrow Zn(OH)_2(s) + Mg(NO_3)_2$

10.26 (a) Combination: (o); decomposition: (l), (s); metathesis: (k), (m), (n), (q), (t); none of these: (p), (r)
(b) Oxidation-reduction: (p), (r), (s)

10.28 (a) $C + \frac{1}{2}O_2 \longrightarrow CO$ (b) $2S + 3O_2 \longrightarrow 2SO_3$ (e) $P_4 + 6H_2 \longrightarrow 4PH_3$
(c) N_2, O_2 (d) C, S (f) Mg, H_2

10.29 (a) $K_2O + H_2O \longrightarrow 2KOH$
(b) $BaO + H_2O \longrightarrow Ba(OH)_2$
(c) CaO (d) Al_2O_3

10.30 (a) $CO_2 + H_2O \longrightarrow H_2CO_3$
(b) $SO_2 + H_2O \longrightarrow H_2SO_3$
(d) $SO_3 + H_2O \longrightarrow H_2SO_4$
(c) P_4O_{10}

10.31 (a) $MgCO_3 \xrightarrow{\Delta} MgO + CO_2$
(b) $2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$
(c) $2KHCO_3 \xrightarrow{\Delta} K_2CO_3 + CO_2 + H_2O$
(d) $Ba(NO_3)_2 \cdot H_2O \xrightarrow{\Delta} Ba(NO_3)_2 + H_2O$
(f) $2NaNO_3 \xrightarrow{\Delta} 2NaNO_2 + O_2$
(e) H_2O (g) SO_3

10.33 (a) Li is oxidized from 0 to +1 in LiCl. The H in HCl is reduced from +1 to 0 in H_2.
(b) Si is oxidized from 0 to +4 in SiF_4. F is reduced from 0 in F_2 to –1 in SiF_4.
(c) H is oxidized from 0 in H_2 to +1 in HCl. Cl is oxidized from 0 in Cl_2 to –1 in HCl.
(d) S is oxidized from –2 to +4. O is reduced from 0 to –2.
(e) Fe is reduced. H is oxidized.

10.34 (c) $Zn + 2CuNO_3(aq) \longrightarrow Zn(NO_3)_2(aq) + 2Cu(s)$

10.37 Soluble: (g), (l), (m); insoluble: (h), (i), (j), (k)

10.38 (a) To begin, first write individually all of the ions in the reactants:

$NiCl_2(aq) + Ca(OH)_2(aq) \longrightarrow$

$Ni^{2+}\ Cl^-$ $\quad$ $Ca^{2+}\ OH^-$

Combine Ni^{2+} with OH^- to produce one product, $Ni(OH)_2$

Combine Ca^{2+} with Cl^- to form the other product $CaCl_2$

Referring to Table 10.4 to determine the solubility of the two products, we see that $Ni(OH)_2$ is insoluble and $CaCl_2$ is soluble.

$NiCl_2(aq) + Ca(OH)_2(aq) \longrightarrow Ni(OH)_2(s) + CaCl_2(aq)$ (Balanced)

(b) To begin, first write individually all of the ions in the reactants:

$Hg(C_2H_3O_2)_2(aq) + K_2CO_3(aq) \longrightarrow$

$Hg^{2+}\ C_2H_3O_2^-$ $\quad$ $K^+\ CO_3^{2-}$

Combine Hg^{2+} with CO_3^{2-} to produce one product, $HgCO_3$

Combine K^+ with $C_2H_3O_2^-$ to form the other product $KC_2H_3O_2$

Referring to Table 10.4 to determine the solubility of the two products, we see that $HgCO_3$ is insoluble and $KC_2H_3O_2$ is soluble.

$Hg(C_2H_3O_2)_2(aq) + K_2CO_3(aq) \longrightarrow HgCO_3(s) + KC_2H_3O_2(aq)$ (Unbalanced)

$Hg(C_2H_3O_2)_2(aq) + K_2CO_3(aq) \longrightarrow HgCO_3(s) + 2KC_2H_3O_2(aq)$ (Balanced)

(c) To begin, first write individually all of the ions in the reactants:

$H_3PO_4(aq) + AgNO_3(aq) \longrightarrow$

$H^+\ PO_4^{3-}$ $\quad$ $Ag^+\ NO_3^-$

Combine H^+ with NO_3^- to produce one product, HNO_3

Combine Ag^+ with PO_4^{3-} to form the other product Ag_3PO_4

Referring to Table 10.4 to determine the solubility of the two products, we see that Ag_3PO_4 is insoluble and HNO_3 is soluble.

$H_3PO_4(aq) + AgNO_3(aq) \longrightarrow Ag_3PO_4(s) + HNO_3(aq)$ (Unbalanced)

$H_3PO_4(aq) + 3AgNO_3(aq) \longrightarrow Ag_3PO_4(s) + 3HNO_3(aq)$ (Balanced)

(d) To begin, first write individually all of the ions in the reactants:

$H_2SO_3(aq) + Al(OH)_3(aq) \longrightarrow$

$H^+\ SO_3^{2-}$ $\quad$ $Al^{3+}\ OH^-$

Combine H^+ with OH^- to form H_2O.

Combine Al^{3+} with SO^{2-} to form the other product, $Al_2(SO_3)_3$.

Referring to Table 10.4 to determine the solubility of the products, we see that $Al_2(SO_3)_3$ is insoluble.

$H_2SO_3(aq) + Al(OH)_3(aq) \longrightarrow Al_2(SO_3)_3(s) + H_2O(l)$ (Unbalanced)

$3H_2SO_3(aq) + 2Al(OH)_3(aq) \longrightarrow Al_2(SO_3)_3(s) + 6H_2O(l)$

(e) $(NH_4)_2S(aq) + BaI_2(aq) \longrightarrow BaS(s) + 2NH_4I(aq)$

(f) $Cs_2CO_3(aq) + 2HC_2H_3O_2(aq) \longrightarrow 2CsC_2H_3O_2(aq) + CO_2(g) + H_2O(l)$

(g) $Li_2SO_4(aq) + Co(NO_3)_2(aq) \longrightarrow CoSO_4(s) + 2LiNO_3(aq)$

(h) $NH_4CN(aq) + HBr(aq) \longrightarrow NH_4Br(aq) + HCN(g)$

10.39 (l) $2Fe(C_2H_3O_2)_3(aq) + 3K_2S(aq) \longrightarrow Fe_2S_3(s) + 6KC_2H_3O_2(aq)$

(m) $NaC_2H_3O_2(aq) + Pb(C_2H_3O_2)_2(aq) \longrightarrow$ no reaction

10.39 (n) $HgNO_3(aq) + 2NH_4Cl(aq) \longrightarrow Hg_2Cl_2(s) + 2NH_4NO_3(aq)$
(o) $2NaI(aq) + Ag_2SO_4(s) \longrightarrow Na_2SO_3(aq) + 2AgI(s)$
(p) $3Cs_2CO_3(s) + 2Fe(C_2H_3O_2)_3(aq) \longrightarrow 6CsC_2H_3O_2(aq) + Fe_2(CO_3)_3(s)$
(q) $H_2SO_3(aq) + 2RbOH(aq) \longrightarrow Rb_2SO_4(aq) + 2H_2O(l)$
(r) $MgCl_2(aq) + 2AgNO_3(aq) \longrightarrow 2AgCl(s) + Mg(NO_3)_2(aq)$
(s) $3LiHCO_3(aq) + H_3PO_3(aq) \longrightarrow Li_3PO_3(aq) + 3CO_2(g) + 3H_2O(l)$

10.41 (a) $1.00\ \text{g } C_8H_{18} \times \frac{1\ \text{mol } C_8H_{18}}{144\ \text{g } C_8H_{18}} \times \frac{-5450\ \text{kJ}}{1\ \text{mol } C_8H_{18}} = -47.7\ \text{kJ}$

(b) $\frac{1}{1.00\ \text{kg}} \times \frac{1\ \text{kg}}{1000\ \text{g}} \times \frac{47.7\ \text{kJ}}{1} \times \frac{1000\ \text{J}}{1\ \text{kJ}} \times \frac{1\ \text{g °C}}{4.184\ \text{J}} = 11.4\ °C = \Delta T$

Maximum temperature = 25°C + 11.4°C = 36°C

10.43 (a) $C_6H_6 + 15/2O_2 \longrightarrow 6CO_2 + 3H_2O$

(c) $154\ \text{g } CO_2 \times \frac{1\ \text{mol } CO_2}{44.0\ \text{g } CO_2} \times \frac{1\ \text{mol } C_6H_6}{6\ \text{mol } CO_2} \times \frac{-3270\ \text{kJ}}{1\ \text{mol } C_6H_6} = -1910\ \text{kJ}$

(b) –378 kJ (d) 1.12 g C_6H_6

10.44 (a) Heat is a reactant - endothermic. (c) Heat is a product - exothermic.
(b) Endothermic (d) Exothermic

10.47 (f) ... *can be* a precipitate (g) ... undergo *exothermic* reactions.
(h) ... bonds are *formed,* ... (i) ... electrons are *realsed.*
(j) *Exothermic* reactions release...*endothermic* reactions absorbe...

10.48 (c) $2NO + O_2 \longrightarrow 2NO_2$ (d) $2NO_2 + H_2O \longrightarrow HNO_3 + HNO_2$

10.49 (5) $CaC_2 + N_2 \xrightarrow[\Delta]{1100°C} CaCN_2 + C$

(6) $CaCN_2 + C + Na_2CO_3 \longrightarrow 2NaCN + CaCO_3$
(7) $2NaCN + H_2SO_4 \longrightarrow 2HCN + Na_2SO_4$

10.50 (b) $Ca_5(PO_4)_3F + 7H_3PO_4 \longrightarrow HF + 5Ca(H_2PO_4)_2$

CHAPTER ELEVEN

STOICHIOMETRY

11.20 $5\ \cancel{N_2\ \text{molecules}} \times \frac{1\ O_2\ \text{molecule}}{1\ \cancel{N_2\ \text{molecules}}} = 5\ O_2\ \text{molecules}$

$5\ \cancel{N_2\ \text{molecules}} \times \frac{2\ NO\ \text{molecule}}{1\ \cancel{N_2\ \text{molecules}}} = 10\ NO\ \text{molecules}$

$6.02 \times 10^{23}\ \cancel{N_2\ \text{molecules}} \times \frac{1\ O_2\ \text{molecule}}{1\ \cancel{N_2\ \text{molecule}}} = 6.02 \times 10^{23}\ O_2\ \text{molecules}$

$6.02 \times 10^{23}\ \cancel{N_2\ \text{molecules}} \times \frac{2\ NO\ \text{molecule}}{1\ \cancel{N_2\ \text{molecule}}} = 1.20 \times 10^{24}\ NO\ \text{molecules}$

$5.0\ \cancel{\text{mol}\ N_2} \times \frac{1\ \text{mol}\ O_2}{1\ \cancel{\text{mol}\ N_2}} = 5.0\ \text{mol}\ O_2$

$5.0\ \cancel{\text{mol}\ N_2} \times \frac{2\ \text{mol}\ NO}{1\ \cancel{\text{mol}\ N_2}} = 10\ \text{mol}\ NO$

$16.0\ \cancel{g\ O_2} \times \frac{1\ \cancel{\text{mol}\ O_2}}{32.0\ \cancel{g\ O_2}} \times \frac{1\ \cancel{\text{mol}\ N_2}}{1\ \cancel{\text{mol}\ O_2}} \times \frac{28.0\ g\ N_2}{1\ \cancel{\text{mol}\ N_2}} = 14.0\ g\ N_2$

$16.0\ \cancel{g\ O_2} \times \frac{1\ \cancel{\text{mol}\ O_2}}{32.0\ \cancel{g\ O_2}} \times \frac{2\ \cancel{\text{mol}\ NO}}{1\ \cancel{\text{mol}\ O_2}} \times \frac{30.0\ g\ NO}{1\ \cancel{\text{mol}\ NO}} = 30.0\ g\ NO$

$19.5\ \cancel{g\ NO} \times \frac{1\ \cancel{\text{mol}\ NO}}{30.0\ \cancel{g\ NO}} \times \frac{1\ \cancel{\text{mol}\ N_2}}{2\ \cancel{\text{mol}\ NO}} \times \frac{28.0\ g\ N_2}{1\ \cancel{\text{mol}\ N_2}} = 9.10\ g\ N_2$

$19.5\ \cancel{g\ NO} \times \frac{1\ \cancel{\text{mol}\ NO}}{30.0\ \cancel{g\ NO}} \times \frac{1\ \cancel{\text{mol}\ O_2}}{2\ \cancel{\text{mol}\ NO}} \times \frac{32.0\ g\ O_2}{1\ \cancel{\text{mol}\ N_2}} = 10.4\ g\ O_2$

11.22 (a) $1\ \cancel{\text{mol}\ Ca} \times \frac{1\ \text{mol}\ CaF_2}{1\ \cancel{\text{mol}\ Ca}} = 1\ \text{mol}\ CaF_2$

(b) $1\ \cancel{\text{mol}\ Ca} \times \frac{1\ \cancel{\text{mol}\ CaF_2}}{1\ \cancel{\text{mol}\ Ca}} \times \frac{17\ g\ CaF_2}{1\ \cancel{\text{mol}\ CaF_2}} = 78\ g\ CaF_2$

11.24 (a) $5.0\ \cancel{\text{mol}\ Al} \times \frac{2\ \text{mol}\ AlCl_3}{2\ \cancel{\text{mol}\ Al}} = 5.0\ \text{mol}\ AlCl_3$

(b) $8.0\ \cancel{\text{mol}\ Cl_2} \times \frac{2\ \text{mol}\ AlCl_3}{3\ \cancel{\text{mol}\ Cl_2}} = 5.3\ \text{mol}\ AlCl_3$

(c) 18 mol $AlCl_3$ (d) 22 mol $AlCl_3$ (e) 0.019 mol $AlCl_3$

11.27 (a) $0.44\ \cancel{\text{mol}\ FeS_2} \times \frac{2\ \text{mol}\ Fe_2O_3}{4\ \cancel{\text{mol}\ FeS_2}} = 0.22\ \text{mol}\ Fe_2O_3$

$0.44\ \cancel{\text{mol}\ FeS_2} \times \frac{8\ \text{mol}\ SO_2}{4\ \cancel{\text{mol}\ FeS_2}} = 0.88\ \text{mol}\ SO_2$

(b) $29.1\ \cancel{\text{mol}\ FeS_2} \times \frac{2\ \text{mol}\ Fe_2O_3}{4\ \cancel{\text{mol}\ FeS_2}} = 14.6\ \text{mol}\ Fe_2O_3$

$29.1\ \cancel{\text{mol}\ FeS_2} \times \frac{8\ \text{mol}\ SO_2}{4\ \cancel{\text{mol}\ FeS_2}} = 58.2\ \text{mol}\ SO_2$

11.27 (c) $8.200 \text{ mol } O_2 \times \frac{2 \text{ mol } Fe_2O_3}{11 \text{ mol } O_2} = 1.491 \text{ mol } Fe_2O_3$

$8.200 \text{ mol } O_2 \times \frac{8 \text{ mol } SO_2}{11 \text{ mol } O_2} = 5.964 \text{ mol } SO_2$

(d) $19.9 \text{ mmol } O_2 \times \frac{1 \text{ mol}}{1000 \text{ mmol}} \times \frac{2 \text{ mol } Fe_2O_3}{11 \text{ mol } O_2} = 0.00362 \text{ mol } Fe_2O_3$

$19.9 \text{ mmol } O_2 \times \frac{1 \text{ mol}}{1000 \text{ mmol}} \times \frac{8 \text{ mol } SO_2}{11 \text{ mol } O_2} = 0.0145 \text{ mol } SO_2$

(e) $0.00345 \text{ mol } O_2 \times \frac{2 \text{ mol } Fe_2O_3}{11 \text{ mol } O_2} = 6.27 \times 10^{-4} \text{ mol } Fe_2O_3$

$0.00345 \text{ mol } O_2 \times \frac{8 \text{ mol } SO_2}{11 \text{ mol } O_2} = 2.51 \times 10^{-3} \text{ mol } SO_2$

11.28 (a) $17.1 \text{ mol } KClO_3 \times \frac{3 \text{ mol } O_2}{2 \text{ mol } KClO_3} \times \frac{32.0 \text{ g } O_2}{1 \text{ mol } O_2} = 820 \text{ g } O_2$

(b) $1.55 \text{ g } KClO_3 \times \frac{1 \text{ mol } KClO_3}{122 \text{ g } KClO_3} \times \frac{3 \text{ mol } O_2}{2 \text{ mol } KClO_3} = 0.0190 \text{ mol } O_2$

(c) $6.20 \text{ kg } KClO_3 \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol } KClO_3}{122 \text{ g } KClO_3} \times \frac{3 \text{ mol } O_2}{2 \text{ mol } KClO_3} = 75.9 \text{ mol } O_2$

$6.20 \text{ kg } KClO_3 \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol } KClO_3}{122 \text{ g } KClO_3} \times \frac{2 \text{ mol } KCl}{2 \text{ mol } KClO_3} = 50.6 \text{ mol } KCl$

(d) $397 \text{ mg } O_2 \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol } O_2}{32.0 \text{ g } O_2} \times \frac{2 \text{ mol } KClO_3}{3 \text{ mol } O_2} \times \frac{122 \text{ g } KClO_3}{1 \text{ mol } KClO_3}$

$= 1.01 \text{ g } KClO_3$

11.30 (a) $9.22 \text{ mol } Cu_2O \times \frac{6 \text{ mol } Cu}{2 \text{ mol } Cu_2O} \times \frac{63.55 \text{ g Cu}}{1 \text{ mol Cu}} = 1.76 \times 10^3 \text{ g Cu}$

(d) $7.92 \times 10^5 \text{ mol } Cu_2S \times \frac{6 \text{ mol Cu}}{1 \text{ mol } Cu_2S} \times \frac{63.55 \text{ g Cu}}{1 \text{ mol Cu}} = 3.02 \times 10^8 \text{ g Cu}$

(b) 970 g Cu (c) 0.238 g Cu (e) 7.489×10^5 g Cu (f) 1.50 g Cu

11.31 (a) $0.3811 \text{ g } Ag_2O \times \frac{1 \text{ mol } Ag_2O}{231.8 \text{ g } Ag_2O} \times \frac{4 \text{ mol Ag}}{2 \text{ mol } Ag_2O} \times \frac{107.9 \text{ g Ag}}{1 \text{ mol Ag}}$

$= 0.3548 \text{ g Ag}$

(c) $6.22 \text{ mg } Ag_2O \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ mol } Ag_2O}{231.8 \text{ g } Ag_2O} \times \frac{4 \text{ mol Ag}}{2 \text{ mol } Ag_2O} \times \frac{107.9 \text{ g Ag}}{1 \text{ mol Ag}}$

$= 0.00579 \text{ g Ag}$

(b) 7.36×10^3 g Ag (d) 5.104×10^4 g Ag

11.33 (a) $33.4 \text{ g } Cl_2 \times \frac{1 \text{ mol } Cl_2}{70.9 \text{ g } Cl_2} \times \frac{1 \text{ mol } CH_4}{4 \text{ mol } Cl_2} \times \frac{16.0 \text{ g } CH_4}{1 \text{ mol } CH_4} = 1.89 \text{ g } CH_4$

(b) $9336 \text{ g } CCl_4 \times \frac{1 \text{ mol } CCl_4}{153.8 \text{ g } CCl_4} \times \frac{4 \text{ mol } Cl_2}{1 \text{ mol } CCl_4} \times \frac{70.9 \text{ g } Cl_2}{1 \text{ mol } Cl_2}$

$= 1.722 \times 10^4 \text{ g } Cl_2$

11.33 (c) $4.02\ \text{mg HCl} \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{1\ \text{mol HCl}}{36.5\ \text{g HCl}} \times \frac{1\ \text{mol CH}_4}{4\ \text{mol HCl}} \times \frac{16.0\ \text{g CH}_4}{1\ \text{mol CH}_4}$

$= 4.42 \times 10^{-4}\ \text{g CH}_4$

(d) $800.0\ \text{kg CCl}_4 \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mol CCl}_4}{153.8\ \text{g CCl}_4} \times \frac{1\ \text{mol CH}_4}{1\ \text{mol CCl}_4} \times \frac{16.04\ \text{g CH}_4}{1\ \text{mol CH}_4}$

$= 8.343 \times 10^4\ \text{g CH}_4$

$800.0\ \text{kg CCl}_4 \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mol CCl}_4}{153.8\ \text{g CCl}_4} \times \frac{4\ \text{mol Cl}_2}{1\ \text{mol CCl}_4} \times \frac{70.90\ \text{g Cl}_2}{1\ \text{mol Cl}_2}$

$= 1.475 \times 10^6\ \text{g Cl}_2$

11.35 (a) $100.0\ \text{g XeOF}_4 \times \frac{1\ \text{mol XeOF}_4}{223.3\ \text{g XeOF}_4} \times \frac{6\ \text{mol XeF}_4}{2\ \text{mol XeOF}_4} \times \frac{207.3\ \text{g XeF}_4}{1\ \text{mol XeF}_4}$

$= 278.5\ \text{g XeF}_4$

(b) $0.0984\ \text{g HF} \times \frac{1\ \text{mol HF}}{20.0\ \text{g HF}} \times \frac{6\ \text{mol XeF}_4}{16\ \text{mol HF}} \times \frac{207\ \text{g XeF}_4}{1\ \text{mol XeF}_4} = 0.382\ \text{g XeF}_4$

(c) $0.01144\ \text{g XeF}_4 \times \frac{1\ \text{mol XeF}_4}{207.3\ \text{g XeF}_4} \times \frac{8\ \text{mol H}_2\text{O}}{6\ \text{mol XeF}_4} \times \frac{18.02\ \text{g H}_2\text{O}}{1\ \text{mol H}_2\text{O}}$

$= 1.324 \times 10^{-3}\ \text{g H}_2\text{O}$

(d) $3.48\ \text{mg XeF}_4 \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{1\ \text{mol XeF}_4}{207\ \text{g XeF}_4} \times \frac{2\ \text{mol XeOF}_4}{6\ \text{mol XeF}_4} \times \frac{223\ \text{g XeOF}_4}{1\ \text{mol XeOF}_4}$

$= 1.25 \times 10^{-3}\ \text{g XeOF}_4$

$3.48\ \text{mg XeF}_4 \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{1\ \text{mol XeF}_4}{207\ \text{g XeF}_4} \times \frac{4\ \text{mol Xe}}{6\ \text{mol XeF}_4} \times \frac{131\ \text{g Xe}}{1\ \text{mol Xe}}$

$= 1.47 \times 10^{-3}\ \text{g Xe}$

$3.48\ \text{mg XeF}_4 \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{1\ \text{mol XeF}_4}{207\ \text{g XeF}_4} \times \frac{16\ \text{mol HF}}{6\ \text{mol XeF}_4} \times \frac{20.0\ \text{g HF}}{1\ \text{mol HF}}$

$= 8.96 \times 10^{-4}\ \text{g HF}$

$3.48\ \text{mg XeF}_4 \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{1\ \text{mol XeF}_4}{207\ \text{g XeF}_4} \times \frac{3\ \text{mol O}_2}{6\ \text{mol XeF}_4} \times \frac{32.0\ \text{g O}_2}{1\ \text{mol O}_2}$

$= 2.68 \times 10^{-4}\ \text{g O}_2$

11.37 (c) $581.0\ \text{g KNO}_3 \times \frac{1\ \text{mol KNO}_3}{101.1\ \text{g KNO}_3} \times \frac{2\ \text{mol KNO}_2}{2\ \text{mol KNO}_3} \times \frac{85.11\ \text{g KNO}_2}{1\ \text{mol KNO}_2}$

$= 489.1\ \text{g KNO}_2$

(d) $4.760\ \text{kg KNO}_3 \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mol KNO}_3}{101.1\ \text{g KNO}_3} \times \frac{1\ \text{mol O}_2}{2\ \text{mol KNO}_3} \times \frac{32.00\ \text{g O}_2}{1\ \text{mol O}_2}$

$= 753.1\ \text{g O}_2$

11.39 (b) $58.5\ \text{g Sb}_2\text{S}_3 \times \frac{1\ \text{mol Sb}_2\text{S}_3}{340\ \text{g Sb}_2\text{S}_3} \times \frac{3\ \text{mol Fe}}{1\ \text{mol Sb}_2\text{S}_3} \times \frac{55.8\ \text{g Fe}}{1\ \text{mol Fe}} = 28.9\ \text{g Fe}$

(c) $94.7\ \text{kg Sb}_2\text{S}_3 \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mol Sb}_2\text{S}_3}{340\ \text{g Sb}_2\text{S}_3} \times \frac{2\ \text{mol Sb}}{1\ \text{mol Sb}_2\text{S}_3} \times \frac{122\ \text{g Sb}}{1\ \text{mol Sb}}$

$= 6.79 \times 10^4\ \text{g Sb}$

11.39 (d) $5.097\ \text{g Sb} \times \frac{1\ \text{mol Sb}}{121.8\ \text{g Sb}} \times \frac{1\ \text{mol } Sb_2S_3}{2\ \text{mol Sb}} \times \frac{339.5\ \text{g } Sb_2S_3}{1\ \text{mol } Sb_2S_3}$

$= 7.110\ \text{g } Sb_2S_3$

$5.097\ \text{g Sb} \times \frac{1\ \text{mol Sb}}{121.8\ \text{g Sb}} \times \frac{3\ \text{mol Fe}}{2\ \text{mol Sb}} \times \frac{55.85\ \text{g Fe}}{1\ \text{mol Fe}} = 3.507\ \text{g Fe}$

11.40 (a) $569\ \text{kJ} \times \frac{1000\ \text{J}}{1\ \text{kJ}} \times \frac{1\ \text{cal}}{4.184\ \text{J}} \times \frac{1\ \text{kcal}}{1000\ \text{cal}} = 136\ \text{kcal}$

$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g) + 136\ \text{kcal}$

(b) $408\ \text{kJ} \times \frac{2\ \text{mol } H_2}{569\ \text{kJ}} \times \frac{2.02\ \text{g } H_2}{1\ \text{mol } H_2} = 2.89\ \text{g } H_2$

$408\ \text{kJ} \times \frac{2\ \text{mol } H_2}{569\ \text{kJ}} \times \frac{32.0\ \text{g } O_2}{1\ \text{mol } O_2} = 22.9\ \text{g } O_2$

(c) $2.93\ \text{mol } H_2 \times \frac{569\ \text{kJ}}{2\ \text{mol } H_2} = 834\ \text{kJ}$

(d) $2.93\ \text{g } O_2 \times \frac{1\ \text{mol } O_2}{32.0\ \text{g } O_2} \times \frac{569\ \text{kJ}}{1\ \text{mol } O_2} = 52.1\ \text{kJ}$

11.42 (a) $1.00\ \text{g } C_2H_4 \times \frac{1\ \text{mol } C_2H_4}{28\ \text{g } C_2H_4} \times \frac{1.41 \times 10^3\ \text{kJ}}{1\ \text{mol } C_2H_4} = 50.3\ \text{kJ}$

(b) $646\ \text{J} \times \frac{1\ \text{kJ}}{1000\ \text{J}} \times \frac{1\ \text{mol } C_2H_6}{1.41 \times 10^3\ \text{kJ}} \times \frac{28.0\ \text{g } C_2H_4}{1\ \text{mol } C_2H_4} = 0.0128\ \text{g } C_2H_4$

(c) $5.96\ \text{g } O_2 \times \frac{1\ \text{mol } O_2}{32.0\ \text{g } O_2} \times \frac{1.41 \times 10^3\ \text{kJ}}{1\ \text{mol } O_2} = 87.5\ \text{kJ}$

(d) $2.75\ \text{kcal} \times \frac{1000\ \text{cal}}{1\ \text{kcal}} \times \frac{4.184\ \text{J}}{1\ \text{cal}} \times \frac{1\ \text{kJ}}{1000\ \text{J}} \times \frac{1\ \text{mol } C_2H_4}{1.41 \times 10^3\ \text{kJ}} \times \frac{28.0\ \text{g } C_2H_4}{1\ \text{mol } C_2H_4}$

$= 0.229\ \text{g } C_2H_4$

11.44 (a) $\frac{100\ \text{g } CaCO_3}{1\ \text{mol } CaCO_3} \times \frac{1.78\ \text{kJ}}{1.001\ \text{g } CaCO_3} = \frac{178\ \text{kJ}}{\text{mol } CaCO_3}$

$CaCO_3 + 178\ \text{kJ} \longrightarrow CaO + O_2$

(b) $\frac{178\ \text{kJ}}{1\ \text{mol } CaCO_3} \times \frac{1000\ \text{J}}{1\ \text{kJ}} \times \frac{1\ \text{cal}}{4.184\ \text{J}} \times \frac{1\ \text{kcal}}{1000\ \text{cal}} = \frac{42.5\ \text{kcal}}{\text{mol } CaCO_3}$

$CaCO_3 + 42.5\ \text{Kcal} \longrightarrow CaO + O_2$

11.45 $\Delta T = 41.7°C - 23.8°C = 17.9°C$

Mass of reacting solutions = 300.0 g

$300.0\ \text{g} \times 17.9\ ^\circ\text{C} \times \frac{4.18\ \text{J}}{1\ \text{g}\ ^\circ\text{C}} = 2.24 \times 10^4\ \text{J} = 22.4\ \text{kJ}$

11.46 Heat gained by solution:

$\Delta T = 25.4\ °C - 22.2°C = 3.2°C$

$100\ \text{g} \times 3.2\ ^\circ\text{C} \times \frac{4.184\ \text{J}}{\text{g}\ ^\circ\text{C}} = 1.3 \times 10^3\ \text{J}$

11.46 Heat of solution = -1.3×10^3 J

$$\frac{17.0 \text{ g } NH_3}{1 \text{ mol } NH_3} \times \frac{-1.3 \times 10^3 \text{ J}}{0.75 \text{ g } NH_3} = \frac{-3.0 \times 10^4 \text{ J}}{\text{mol } NH_3}$$

11.47 (a) Identify which reactant is limiting by comparing the number of moles of each one.

$$1.53 \text{ g } H_2 \times \frac{1 \text{ mol } H_2}{2.02 \text{ g } H_2} = 0.757 \text{ mol } H_2$$

$$126 \text{ g } I_2 \times \frac{1 \text{ mol } I_2}{254 \text{ g } I_2} = 0.496 \text{ mol } I_2 \text{ available}$$

$$0.757 \text{ mol } H_2 \times \frac{1 \text{ mol } I_2}{1 \text{ mol } H_2} = 0.757 \text{ mol } I_2 \text{ required}$$

I_2 is the limiting reactant because there is not enough I_2 to react with all of the H_2.

$$0.496 \text{ mol } H_2 \times \frac{2 \text{ mol HI}}{1 \text{ mol } H_2} \times \frac{128 \text{ g HI}}{1 \text{ mol HI}} = 127 \text{ g HI}$$

(b) $$8.87 \text{ g } H_2 \times \frac{1 \text{ mol } H_2}{2.02 \text{ g } H_2} = 4.39 \text{ mol } H_2$$

$$1025 \text{ g } I_2 \times \frac{1 \text{ mol } I_2}{253.8 \text{ g } I_2} = 4.039 \text{ mol } I_2 \text{ available}$$

$$4.39 \text{ mol } H_2 \times \frac{1 \text{ mol } I_2}{1 \text{ mol } H_2} = 4.39 \text{ mol } I_2 \text{ required}$$

I_2 is limiting.

$$4.039 \text{ mol } H_2 \times \frac{2 \text{ mol HI}}{1 \text{ mol } H_2} \times \frac{127.9 \text{ g HI}}{1 \text{ mol HI}} = 1033 \text{ g HI}$$

(c) $$0.3462 \text{ g } H_2 \times \frac{1 \text{ mol } H_2}{2.016 \text{ g } H_2} = 0.1717 \text{ mol } H_2$$

$$45.92 \text{ g } I_2 \times \frac{1 \text{ mol } I_2}{253.8 \text{ g } I_2} = 0.1809 \text{ mol } I_2$$

$$0.1717 \text{ mol } H_2 \times \frac{1 \text{ mol } I_2}{1 \text{ mol } H_2} = 0.1717 \text{ mol } I_2 \text{ used}$$

$0.1809 \text{ mol } I_2 - 0.171 \text{ mol } I_2 = 0.0092 \text{ mol } I_2$ remain

$$0.0092 \text{ mol } H_2 \times \frac{254 \text{ g } I_2}{1 \text{ mol } H_2} = 2.3 \text{ g } I_2 \text{ remain}$$

11.49 (a) What is the limiting reagent?

$$970.0 \text{ g NaCl} \times \frac{1 \text{ mol NaCl}}{58.44 \text{ g NaCl}} = 16.60 \text{ mol NaCl}$$

$$970.0 \text{ g } H_2SO_4 \times \frac{1 \text{ mol } H_2SO_4}{98.08 \text{ g } H_2SO_4} = 9.890 \text{ mol } H_2SO_4$$

$$16.60 \text{ mol NaCl} \times \frac{1 \text{ mol } H_2SO_4}{2 \text{ mol NaCl}} = 8.300 \text{ mol } H_2SO_4 \text{ required}$$

NaCl must be the limiting reagent since enough H_2SO_4 is present to react with all of the NaCl.

11.49 (a) $16.60 \text{ mol NaCl} \times \frac{1 \text{ mol } Na_2SO_4}{2 \text{ mol NaCl}} \times \frac{142.0 \text{ g } Na_2SO_4}{1 \text{ mol } Na_2SO_4} = 1179 \text{ g } Na_2SO_4$

(b) $35.7 \text{ g NaCl} \times \frac{1 \text{ mol NaCl}}{58.4 \text{ g NaCl}} = 0.611 \text{ mol NaCl}$

$21.9 \text{ g } H_2SO_4 \times \frac{1 \text{ mol } H_2SO_4}{98.1 \text{ g } H_2SO_4} = 0.223 \text{ mol } H_2SO_4 \text{ available}$

$0.611 \text{ mol NaCl} \times \frac{1 \text{ mol } H_2SO_4}{2 \text{ mol NaCl}} = 0.306 \text{ mol } H_2SO_4 \text{ required}$

H_2SO_4 is the limiting reagent.

$0.223 \text{ mol } H_2SO_4 \times \frac{1 \text{ mol } Na_2SO_4}{1 \text{ mol } H_2SO_4} \times \frac{142 \text{ g } Na_2SO_4}{1 \text{ mol } Na_2SO_4} = 31.7 \text{ g } Na_2SO_4$

(c) $12.2 \text{ kg NaCl} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol NaCl}}{58.4 \text{ g NaCl}} = 209 \text{ mol NaCl}$

$9.75 \text{ kg } H_2SO_4 \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol } H_2SO_4}{98.1 \text{ g } H_2SO_4} = 99.4 \text{ mol } H_2SO_4 \text{ available}$

$209 \text{ mol NaCl} \times \frac{1 \text{ mol } H_2SO_4}{2 \text{ mol NaCl}} = 104 \text{ mol } H_2SO_4 \text{ required}$

The limiting reagent is H_2SO_4.

$99.4 \text{ mol } H_2SO_4 \times \frac{2 \text{ mol HCl}}{1 \text{ mol } H_2SO_4} \times \frac{36.5 \text{ g HCl}}{1 \text{ mol HCl}} = 7.24 \times 10^3 \text{ g HCl}$

(d) The mass of NaCl reacted is:

$99.4 \text{ mol } H_2SO_4 \times \frac{2 \text{ mol NaCl}}{1 \text{ mol } H_2SO_4} = 199 \text{ mol NaCl}$

209 mol NaCl – 199 mol NaCl = 10 mol NaCl left.

$10 \text{ mol NaCl} \times \frac{58.4 \text{ g NaCl}}{1 \text{ mol NaCl}} = 5.8 \times 10^2 \text{ g NaCl}$

11.51 (a) First write the balanced equation.

$Na_2CO_3 + 4C + N_2 \longrightarrow 3CO + 2NaCN$

Identify the limiting reagent.

$36.5 \text{ g C} \times \frac{1 \text{ mol C}}{12.0 \text{ g C}} = 3.04 \text{ mol C}$

$81.4 \text{ g } Na_2CO_3 \times \frac{1 \text{ mol } Na_2CO_3}{106 \text{ g } Na_2CO_3} = 0.768 \text{ mol } Na_2COs \text{ available}$

$3.04 \text{ mol C} \times \frac{1 \text{ mol } Na_2CO_3}{4 \text{ mol C}} = 0.760 \text{ mol } Na_2CO_3 \text{ required}$

The limiting reagent is C.

$3.04 \text{ mol C} \times \frac{2 \text{ mol NaCN}}{4 \text{ mol C}} \times \frac{49.0 \text{ g NaCN}}{1 \text{ mol NaCN}} = 74.5 \text{ g NaCN}$

(b) $3.04 \text{ mol C} \times \frac{1 \text{ mol } N_2}{4 \text{ mol C}} \times \frac{28.0 \text{ g } N_2}{1 \text{ mol } N_2} = 21.3 \text{ g } N_2$

11.52 (a) First write the balanced equation.

$C_6H_6 + Cl_2 \longrightarrow C_6H_5Cl + HCl$

11.52 (a) $13.0\ \text{g } C_6H_6 \times \frac{1\ \text{mol } C_6H_6}{78.0\ \text{g } C_6H_6} \times \frac{1\ \text{mol } C_6H_5Cl}{1\ \text{mol } C_6H_6} \times \frac{112\ \text{g } C_6H_5Cl}{1\ \text{mol } C_6H_5Cl}$

$= 18.7\ \text{g } C_6H_5Cl$

(b) % C_6H_5Cl = (actual yield/theoretical yield) × 100

= (10.4 g/18.7 g) × 100 = 55.6%

(c) First calculate the theoretical yield.

$2.87\ \text{g } C_6H_6 \times \frac{1\ \text{mol } C_6H_6}{78.0\ \text{g } C_6H_6} \times \frac{1\ \text{mol } C_6H_5Cl}{1\ \text{mol } C_6H_6} \times \frac{112\ \text{g } C_6H_5Cl}{1\ \text{mol } C_6H_5Cl}$

$= 4.12\ \text{g } C_6H_5Cl$

64.3% = (actual yield × 100)/4.12 g C_6H_5Cl

actual yield = 2.65 g C_6H_5Cl

(d) First calculate the required theoretical yield.

59.2% = (4.92 g C_6H_5Cl × 100)/theoretical yield

theoretical yield = 8.31 g C_6H_5Cl

Calculate the mass of C_6H_6 required to form 8.31 g C_6H_5Cl.

$8.31\ \text{g } C_6H_5Cl \times \frac{1\ \text{mol } C_6H_5Cl}{112\ \text{g } C_6H_5Cl} \times \frac{1\ \text{mol } C_6H_6}{1\ \text{mol } C_6H_5Cl} \times \frac{78.0\ C_6H_6}{1\ \text{mol } C_6H_6}$

$= 5.79\ \text{g } C_6H_6$

11.54 First write the balanced equation.

$CaCN_2 + C + Na_2CO_3 \longrightarrow CaCO_3 + 2NaCN$

(a) Calculate the required theoretical yield.

70.1% = (2.953 g NaCN × 100)/theoretical yield

Theoretical yield = 4.21 g NaCN

Now calculate the mass of $CaCN_2$ required.

$4.21\ \text{g NaCN} \times \frac{1\ \text{mol NaCN}}{49.0\ \text{g NaCN}} \times \frac{1\ \text{mol } CaCN_2}{2\ \text{mol NaCN}} \times \frac{80.0\ \text{g } CaCN_2}{1\ \text{mol } CaCN_2}$

$= 3.44\ \text{g } CaCN_2$

(b) 83.9% = (40.47 kg NaCN × 100)/theoretical yield

Theoretical yield = 48.2 kg NaCN

$48.2\ \text{kg NaCN} \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mol NaCN}}{49.0\ \text{g NaCN}} \times \frac{1\ \text{mol } CaCN_2}{2\ \text{mol NaCN}}$

$\times \frac{80.0\ \text{g } CaCN_2}{1\ \text{mol } CaCN_2} = 3.94 \times 10^4\ \text{g } CaCN_2$

11.55 (a) $10.0\ \text{mL soln} \times \frac{0.400\ \text{mol } Na_2CO_3}{1000\ \text{mL soln}} \times \frac{1\ \text{mol } FeCO_3}{1\ \text{mol } Na_2CO_3} \times \frac{116\ \text{g } FeCO_3}{1\ \text{mol } FeCO_3}$

$= 0.464\ \text{g } FeCO_3$

(b) $14.0\ \text{mL soln} \times \frac{0.444\ \text{mol } Na_2CO_3}{1000\ \text{mL soln}} \times \frac{1\ \text{mol } FeCO_3}{1\ \text{mol } Na_2CO_3} \times \frac{116\ \text{g } FeCO_3}{1\ \text{mol } FeCO_3}$

$= 0.721\ \text{g } FeCO_3$

(c) 31.7 g $FeCO_3$

11.56 (a) $10.0\ \text{mL soln} \times \frac{0.400\ \text{mol } Na_2CO_3}{1000\ \text{mL soln}} \times \frac{1\ \text{mol } CO_2}{1\ \text{mol } Na_2CO_3} \times \frac{44.0\ \text{g } CO_2}{1\ \text{mol } CO_2}$

$= 0.176\ \text{g } CO_2$

(b) 0.274 g CO_2 (c) 12.0 g CO_2

11.57 (a) The balanced chemical reaction is

$KOH + HNO_3 \longrightarrow KNO_3 + H_2O$

$5.00\ \text{mL } HNO_3\text{ soln} \times \frac{0.122\ \text{mol } HNO_3}{1000\ \text{mL } HNO_3\text{ soln}} \times \frac{1\ \text{mol KOH}}{1\ \text{mol } HNO_3}$

$\times \frac{1000\ \text{mL KOH soln}}{0.100\ \text{mol KOH}} = 6.10\ \text{mL KOH soln}$

(b) The balanced chemical equation is

$2KOH + H_2SO_3 \longrightarrow K_2SO_3 + 2H_2O$

$5.00\ \text{mL } H_2SO_3\text{ soln} \times \frac{0.122\ \text{mol } H_2SO_3}{1000\ \text{mL } H_2SO_3\text{ soln}} \times \frac{2\ \text{mol KOH}}{1\ \text{mol } H_2SO_3}$

$\times \frac{1000\ \text{mL KOH soln}}{0.100\ \text{mol KOH}} = 12.2\ \text{mL KOH soln}$

(c) 18.3 mL KOH soln

11.58 $HNO_3 + NaOH \longrightarrow NaNO_3 + H_2O$

(a) Determine the limiting reagent.

$75.0\ \text{mL } NHO_3\text{ solution} \times \frac{0.155\ \text{mol } HNO_3}{1000\ \text{mL } HNO_3\text{ solution}} = 0.0116\ \text{mol } HNO_3$

$75.0\ \text{mL NaOH solution} \times \frac{0.155\ \text{mol NaOH}}{1000\ \text{mL NaOH solution}} = 0.0116\ \text{mol NaOH}$

Since the stoichiometric number of moles are present either one may be used to determine the amount of $NaNO_3$ formed.

$0.0166\ \text{mol } HNO_3 \times \frac{1\ \text{mol } NaNO_3}{1\ \text{mol } HNO_3} \times \frac{85.0\ \text{g } NaNO_3}{1\ \text{mol } NaNO_3} = 0.988\ \text{g } NaNO_3$

(b) Determine the limiting reagent.

$65.0\ \text{mL NaOH solution} \times \frac{0.165\ \text{mol NaOH}}{1000\ \text{mL NaOH solution}} = 0.0107\ \text{mol NaOH}$

$0.0107\ \text{mol NaOH} \times \frac{1\ \text{mol } HNO_3}{1\ \text{mol NaOH}} = 0.0107\ \text{mol } HNO_3\text{ required.}$

NaOH is limiting.

$0.0107\ \text{mol NaOH} \times \frac{1\ \text{mol } NaNO_3}{1\ \text{mol NaOH}} \times \frac{85.0\ \text{g } NaNO_3}{1\ \text{mol } NaNO_3} = 0.912\ \text{g } NaNO_3$

(c) 0.988 g $NaNO_3$

11.60 The balanced chemical equation is

$Ba(NO_3)_2 + K_2SO_4 \longrightarrow BaSO_4 + 2KNO_3$

$50.0\ \text{g } BaSO_4 \times \frac{1\ \text{mol } BaSO_4}{233\ \text{g } BaSO_4} \times \frac{1\ \text{mol } Ba(NO_3)_2}{1\ \text{mol } BaSO_4} \times \frac{1000\ \text{mL } Ba(NO_3)_2\text{ soln}}{0.900\ \text{mol } Ba(NO_3)_2}$

$= 238\ \text{mL } Ba(NO_3)_2\text{ soln}$

11.63 (a) $544\ \text{g } CaCO_3 \times \frac{1\ \text{mol } CaCO_3}{100\ \text{g } CaCO_3} \times \frac{1\ \text{mol } CaO}{1\ \text{mol } CaCO_3} \times \frac{1\ \text{mol } Ca(OH)_2}{1\ \text{mol } CaO}$

$$\frac{74.0\ \text{g } Ca(OH)_2}{1\ \text{mol } Ca(OH)_2} = 403\ \text{g } Ca(OH)_2$$

(b) Calculate the theoretical yield.

$53.3\ \text{kg } CaCO_3 \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mol } CaCO_3}{100\ \text{g } CaCO_3} \times \frac{1\ \text{mol } CaO}{1\ \text{mol } CaCO_3}$

$$\frac{1\ \text{mol } Ca(OH)_2}{1\ \text{mol } CaO} \times \frac{74.0\ \text{g } Ca(OH)_2}{1\ \text{mol } Ca(OH)_2} = 3.94 \times 10^4\ \text{g } Ca(OH)_2$$

= theoretical yield

% $Ca(OH)_2$ = (actual yield × 100)/theoretical yield

71.1% $Ca(OH)_2$ = (actual yield × 100)/3.94×10^4 g

actual yield = 2.81×10^4 g $Ca(OH)_2$

11.65 First identify the limiting reactant.

$7.80\ \text{g } KMnO_4 \times \frac{1\ \text{mol } KMnO_4}{158\ \text{g } KMnO_4} = 0.0493\ \text{mol } KMnO_4$

$42.7\ \text{g KI} \times \frac{1\ \text{mol KI}}{166\ \text{g KI}} = 0.257\ \text{mol KI available}$

$19.3\ \text{g } H_2SO_4 \times \frac{1\ \text{mol } H_2SO_4}{98.0\ \text{g } H_2SO_4} = 0.197\ \text{mol } H_2SO_4 \text{ available}$

$0.0493\ \text{mol } KMnO_4 \times \frac{10\ \text{mol KI}}{2\ \text{mol } KMnO_4} = 0.396\ \text{mol KI required}$

$0.0493\ \text{mol } KMnO_4 \times \frac{8\ \text{mol } H_2SO_4}{2\ \text{mol } KMnO_4} = 0.197\ \text{mol } H_2SO_4 \text{ required}$

From these calculations you can see that KI will be the limiting reagent if sufficient H_2SO_4 is available to react with it.

$0.396\ \text{mol KI} \times \frac{8\ \text{mol } H_2SO_4}{10\ \text{mol KI}} = 0.317\ \text{mol } H_2SO_4 \text{ required}$

H_2SO_4 is the limiting reagent.

$0.197\ \text{mol } H_2SO_4 \times \frac{6\ \text{mol } K_2SO_4}{8\ \text{mol } H_2SO_4} \times \frac{174\ \text{g } K_2SO_4}{1\ \text{mol } K_2SO_4} = 25.7\ \text{g } K_2SO_4$

$0.197\ \text{mol } H_2SO_4 \times \frac{2\ \text{mol } MnSO_4}{8\ \text{mol } H_2SO_4} \times \frac{151\ \text{g } MnSO_4}{1\ \text{mol } MnSO_4} = 7.43\ \text{g } MnSO_4$

$0.197\ \text{mol } H_2SO_4 \times \frac{5\ \text{mol } I_2}{8\ \text{mol } H_2SO_4} \times \frac{254\ \text{g } I_2}{1\ \text{mol } I_2} = 31.2\ \text{g } I_2$

11.67 (a) First calculate the theoretical yield.

66.9% SF_4 = (37.8 g × 100)/theoretical yield

Theoretical yield = 56.5 g SF_4

$56.5\ \text{g } SF_4 \times \frac{1\ \text{mol } SF_4}{108\ \text{g } SF_4} \times \frac{3\ \text{mol } SCl_2}{1\ \text{mol } SF_4} \times \frac{103\ \text{g } SCl_2}{1\ \text{mol } SCl_2} = 162\ \text{g } SCl_2$

$56.5\ \text{g } SF_4 \times \frac{1\ \text{mol } SF_4}{108\ \text{g } SF_4} \times \frac{4\ \text{mol NaF}}{1\ \text{mol } SF_4} \times \frac{42.0\ \text{g NaF}}{1\ \text{mol NaF}} = 87.8\ \text{g NaF}$

11.67 (b) Identify the limiting reagent.

$$250.99 \text{ g } SCl_2 \times \frac{1 \text{ mol } SCl_2}{102.97 \text{ g } SCl_2} = 2.4376 \text{ mol } SCl_2$$

$$136.22 \text{ g NaF} \times \frac{1 \text{ mol NaF}}{41.988 \text{ g NaF}} = 3.2443 \text{ mol NaF available}$$

$$2.4376 \text{ mol } SCl_2 \times \frac{4 \text{ mol NaF}}{3 \text{ mol } SCl_2} = 3.2501 \text{ mol NaF required}$$

NaF is the limiting reagent.

$$3.2443 \text{ mol NaF} \times \frac{1 \text{ mol } SF_4}{4 \text{ mol NaF}} \times \frac{108.05 \text{ g } SF_4}{1 \text{ mol } SF_4} = 87.637 \text{g } SF_4$$

Theoritical yield = 87.637 g SF_4

66.9% SF_4 = (actual yield × 100)/87.637 g SF_4

Actual yield = 58.6 g SF_4

11.69 First write the balanced equation.

$2HCl + CaCO_3 \longrightarrow CaCl_2 + CO_2 + H_2O$

Calculate the mass of $CaCO_3$ that reacted to form 0.303 g CO_2.

$$0.303 \text{ g } CO_2 \times \frac{1 \text{ mol } CO_2}{44.0 \text{ g } CO_2} \times \frac{1 \text{ mol } CaCO_3}{1 \text{ mol } CO_2} \times \frac{100 \text{ g } CaCO_3}{1 \text{ mol } CaCO_3}$$

$$= 0.689 \text{ g } CaCO_3$$

% $CaCO_3$ = (0.689 g $CaCO_3$ × 100)/1.000 g sample = 68.9% $CaCO_3$

% $CaSO_4$ = 100.0% - 68.9% $CaCO_3$ = 31.1% $CaSO_4$

11.70 If we represent the formula of the cobalt oxide by Co_xO_y, the balanced equation is

$Co_xO_y + yH_2 \longrightarrow xCo + yH_2O$

Values for *x* and *y* can be determined by converting the masses of H_2 and Co to moles.

$$5.54 \text{ g } H_2 \times \frac{1 \text{ mol } H_2}{2.02 \text{ g } H_2} = 2.74 \text{ mol } H_2 = y$$

$$108 \text{ g Co} \times \frac{1 \text{ mol Co}}{58.9 \text{ g Co}} = 1.83 \text{ mol Co} = x$$

The formula for the compound is $Co_{1.83}O_{2.74}$

To obtain whole numbers divide each subscript by 1.83.

1.83 mol Co/1.83 = 1.00 mol Co

2.74 mol O/1.83 = 1.50 mol O

1.00 mol Co × 2 = 2 mol Co

1.50 mol O × 2 = 3 mol O

The formula is Co_2O_3.

11.72 $\Delta T = 24.1°C - 22.2°C = 1.9°C$

Heat gained by the solution is

11.72 $100\ g \times 1.9\,^{\circ}\cancel{C} \times \frac{4.18\ \cancel{J}}{g\cdot\,^{\circ}\cancel{C}} \times \frac{1\ kJ}{1000\ \cancel{J}} = 0.79\ kJ$

Heat lost by 0.750 g KBr is – 0.79 kJ

$$\frac{80.1\ \cancel{g\ KBr}}{1\ mol\ KBr} \times \frac{-0.79\ kJ}{0.750\ \cancel{g\ KBr}} = \frac{-85\ kJ}{mol\ KBr}$$

11.73 (a) $H_2C_2O_4(s) + 2NaOH(aq) \longrightarrow Na_2C_2O_4(aq) + 2H_2O(l)$

(b) Determine the limiting reagent.

$$5.07\ \cancel{g\ H_2C_2O_4} \times \frac{1\ mol\ H_2C_2O_4}{90.0\ \cancel{g\ H_2C_2O_4}} = 0.0563\ mol\ H_2C_2O_4$$

$$40.5\ \cancel{mL\ soln} \times \frac{2.50\ mol\ NaOH}{1000\ \cancel{mL\ soln}} = 0.101\ mol\ NaOH\ available$$

$$0.563\ \cancel{mol\ H_2C_2O_4} \times \frac{2\ mol\ NaOH}{1\ \cancel{mol\ H_2C_2O_4}} = 0.113\ mol\ NaOH\ required$$

NaOH is the limiting reagent.

$$0.101\ \cancel{mol\ NaOH} \times \frac{1\ \cancel{mol\ Na_2C_2O_4}}{2\ \cancel{mol\ NaOH}} \times \frac{134\ g\ Na_2C_2O_4}{1\ \cancel{mol\ Na_2C_2O_4}} = 478\ g\ Na_2C_2O_4$$

CHAPTER TWELVE

GASES

12.29 (a) 752 torr + 47.1 torr = 799 torr

(b) 752 torr – 53.4 torr = 699 torr

12.31 (a) $4.04 \times 10^3 \text{ kPa} \times \frac{1000 \text{ Pa}}{1 \text{ kPa}} = 4.04 \times 10^6 \text{ Pa}$

(b) $4.04 \times 10^3 \text{ kPa} \times \frac{1000 \text{ Pa}}{1 \text{ kPa}} \times \frac{1 \text{ atm}}{101325 \text{ Pa}} \times \frac{760 \text{ torr}}{1 \text{ atm}} = 3.30 \times 10^4 \text{ torr}$

(c) 39.9 atm (d) 3.03×10^4 mm Hg

12.32 (a) $2.953 \text{ atm} \times \frac{760 \text{ torr}}{1 \text{ atm}} = 2244 \text{ torr}$

(b) 2.992×10^5 Pa (c) 299.2 kPa

12.33 (a) $784 \text{ mm Hg} \times \frac{1 \text{ torr}}{1 \text{ mm Hg}} = 784 \text{ torr}$

(c) $784 \text{ mm Hg} \times \frac{1 \text{ torr}}{1 \text{ mm Hg}} \times \frac{1 \text{ atm}}{760 \text{ torr}} \times \frac{101325 \text{ Pa}}{1 \text{ atm}} = 1.05 \times 10^5 \text{ Pa}$

(b) 1.03 atm (d) 105 kPa

12.34 (c) $9282 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}} \times \frac{101325 \text{ Pa}}{1 \text{ atm}} \times \frac{1 \text{ kPa}}{1000 \text{ Pa}} = 1238 \text{ kPa}$

(a) 12.21 atm (b) 1.238×10^6 Pa

12.36 (a) $\frac{12^2 \text{ in}^2}{1 \text{ ft}^2} \times \frac{14.7 \text{ lb}}{1 \text{ in}^2} = \frac{2.12 \times 10^3 \text{ lb}}{\text{ft}^2}$

(b) $29.0 \text{ psi} \times \frac{1 \text{ atm}}{14.7 \text{ psi}} \times \frac{760 \text{ torr}}{1 \text{ atm}} = 1.50 \times 10^3 \text{ torr}$

12.38 (a) $\frac{1}{2.51 \text{ atm}} \times \frac{0.910 \text{ L·atm}}{1} = 0.362 \text{ L}$

(e) $\frac{1}{93.8 \text{ kPa}} \times \frac{1 \text{ kPa}}{1000 \text{ Pa}} \times \frac{101325 \text{ Pa}}{1 \text{ atm}} \times \frac{0.910 \text{ L·atm}}{1} = .983 \text{ L}$

(b) 0.149 L (c) 20.3 L (d) 2.12 L

12.41 Use Boyle's law with $V_1 = 73.5 \text{ cm}^3$, $P_1 = 296$ atm, and $P_2 = 1$ atm. Solve for V_2.

$V_2 = V_1 \times (P_1/P_2) = 73.5 \text{ cm}^3 \times (296 \text{ atm}/1 \text{ atm})$

$V_2 = 2.18 \times 10^4 \text{ cm}^3$

12.44 (a) Use Boyle's law with $V_1 = 1204$ mL, $P_1 = 1.000$ atm, and $V_2 = 1000$ mL. Solve for P_2.

$P_2 = (P_1 \times V_1)/V_2 = (1.000 \text{ atm} \times 1204 \cancel{\text{mL}})/1000 \cancel{\text{mL}} = 1.204 \text{ atm}$

(b) Use Boyle's law with $Vi = 1204$ mL, $P_1 = 1.000$ atm, and $V_2 = 340.5$ rnL. Solve for P_2.

$P_2 = (P_1 \times V_1)/ V_2 = (1.000 \text{ atm} \times 1204 \cancel{\text{mL}})/340.5 \cancel{\text{mL}} = 3.536 \text{ atm}$

(c) 0.03010 atm (d) 0.1964 atm

12.50 (a) Use Charles' law with $V_1 = 9.35$ L, $T_1 = 282$ K, and $T_2 = 149$ K. Solve for V_2.

$V_2 = (V_1 \times T_2)/T_1 = (9.35 \text{ L} \times 149 \cancel{\text{K}})/282 \cancel{\text{K}} = 4.94 \text{ L}$

(b) $V_1 = 9.35$ L, $T_1 = 282$ K, $T_2 = 596$ K. Solve for V_2.

$V_2 = (9.35 \text{ L} \times 596 \cancel{\text{K}})/282 \cancel{\text{K}} = 19.8 \text{ L}$

(c) $V_1 = 9.35$ L, $T_1 = 282$ K, $T_2 = 298°\text{C} + 273 = 571$ K. Solve for V_2.

$V_2 = (9.35 \text{ L} \times 571 \cancel{\text{K}})/282 \cancel{\text{K}} = 18.9 \text{ L}$

(d) $V_1 = 9.35$ L, $T_1 = 282$ K, $T_2 = 273 - 65°\text{C} = 208$ K. Solve for V_2.

$V_2 = (9.35 \text{ L} \times 208 \cancel{\text{K}})/282 \cancel{\text{K}} = 6.90 \text{ L}$

12.52 (a) Use Charles' law with $V_1 = 5.74$ L, $T_1 = 273.2 + 10.0°\text{C} = 283.2$ K, and $V_2 = 10.0$ L. Solve for T_2.

$T_2 = (V_2 \times T_1)/V_1 = (10.0 \cancel{\text{L}} \times 283.2 \text{ K})/5.74 \text{ L} = 493 \text{ K}$

(b) 296 K (c) 750 K

12.54 (a) An increase in P, with T constant, will result in a decrease in V. A decrease in T, with P constant, will result in a decrease in V. Both of these changes produce a decrease in V.

(c) A small increase in P, at constant T, will result in a small decrease in V. A larger increase in T, at constant P, will result in a larger increase in V. The net result is an increase in V.

(b) V increases (d) V decreases

12.55 Use the combined gas law with $T_2 = 273$ K, and $P_2 = 1$ atm. Solve for V_2.

$V_2 = V_1 \times (P_1 / P_2) \times (T_2/T_1)$

(a) $T_1 = 273 + 58°\text{C} = 331$ K

$$V_2 = 5.90 \text{ L} \times \frac{7.61 \cancel{\text{ atm}}}{1 \cancel{\text{ atm}}} \times \frac{273 \cancel{\text{ K}}}{331 \cancel{\text{ K}}} = 37.0 \text{ L}$$

(c) $$P_1 = 446 \cancel{\text{ kPa}} \times \frac{1000 \cancel{\text{ Pa}}}{1 \cancel{\text{ kPa}}} \times \frac{1 \text{ atm}}{101325 \cancel{\text{ Pa}}} = 4.40 \text{ atm}$$

$$V_2 = 0.446 \text{ L} \times \frac{4.40 \cancel{\text{ atm}}}{1 \cancel{\text{ atm}}} \times \frac{273 \cancel{\text{ K}}}{227 \cancel{\text{ K}}} = 2.36 \text{ L}$$

(b) 314 cm^3 (d) 274 L

12.56 Solve the combined gas law for V_2

$V_2 = V_1 \times (P_1/P_2) \times (T_2/T_1)$

(a) $V_2 = 0.619\ \text{L} \times \frac{1.24\ \cancel{\text{atm}}}{9.49\ \cancel{\text{atm}}} \times \frac{822\ \cancel{\text{K}}}{444\ \cancel{\text{K}}} = 0.150\ \text{L}$

(c) The units must be changed so that they are consistent.

$V_2 = 1.75\ \cancel{\text{L}} \times \frac{1000\ \text{mL}}{1\ \cancel{\text{L}}} = 1.75 \times 10^3\ \text{mL}$

$T_1 = 273.2 + 30.8°\text{C} = 304.0\ \text{K}$

$P_1 = 476\ \text{torr} \times \frac{1\ \text{atm}}{760\ \text{torr}} \times \frac{101325\ \text{Pa}}{1\ \text{atm}} \times \frac{1\ \text{kPa}}{1000\ \text{Pa}} = 63.5\ \text{kPa}$

$V_2 = V_1 \times (P_1/P_2) \times (T_2/T_1)$

$V_2 = 1.75 \times 10^3\ \text{L} \times \frac{63.5\ \cancel{\text{kPa}}}{418\ \cancel{\text{kPa}}} \times \frac{310\ \cancel{\text{K}}}{304.0\ \cancel{\text{K}}} = 271\ \text{mL}$

(b) $1.18 \times 10^3\ \text{mL}$ (d) $9.68 \times 10^3\ \text{cm}^3$

12.57 Solve the combined gas law for P_2

$P_2 = P_1 \times (V_1/V_2) \times (T_2/T_1)$

(a) °C must be converted to K.

$T_2 = 273.2 + 23.5°\text{C} = 296.7\ \text{K}$

$T_1 = 273.2 + 52.2°\text{C} = 325.4\ \text{K}$

$P_2 = 1.79\ \text{atm} \times \frac{89.6\ \cancel{\text{L}}}{43.8\ \cancel{\text{L}}} \times \frac{325.4\ \cancel{\text{K}}}{296.7\ \cancel{\text{K}}} = 4.02\ \text{atm}$

(c) °F must be converted to °C and then to K.

$°\text{C} = 5/9(°\text{F} - 32)$

For T_1, $°\text{C} = 5/9(-23°\text{F} - 32) = -30°\text{C}$

$\text{K} = 273 - 30°\text{C} = 242\ \text{K}$

For T_2, $°\text{C} = 5/9(35°\text{F} - 32) = 2°\text{C}$

$\text{K} = 273 + 2°\text{C} = 275\ \text{K}$

$P_2 = 912\ \text{torr} \times \frac{62.8\ \cancel{\text{L}}}{77.4\ \cancel{\text{L}}} \times \frac{275\ \cancel{\text{K}}}{242\ \cancel{\text{K}}} = 838\ \text{torr}$

(b) $6.27 \times 10^6\ \text{Pa}$ (d) $8.32 \times 10^{-4}\ \text{atm}$

12.59 (a) $372\ \cancel{\text{mL}} \times \frac{1\ \cancel{\text{L}}}{1000\ \cancel{\text{mL}}} \times \frac{1\ \text{mol}}{22.4\ \cancel{\text{L}}} = 0.0166\ \text{mol}$

(d) $2.551\ \cancel{\text{mm}^3} \times \frac{1\ \text{m}^3}{1000^3\ \cancel{\text{mm}^3}} \times \frac{1000\ \cancel{\text{L}}}{1\ \text{m}^3} \times \frac{1\ \text{mol}}{22.4\ \cancel{\text{L}}} = 1.14 \times 10^{-7}\ \text{mol}$

(b) 0.933 mol (c) $1.83 \times 10^{-7}\ \text{mol}$ (e) 367 mol

12.60 (a) $1.94\ \cancel{\text{g NH}_3} \times \frac{1\ \text{mol}\ \cancel{\text{NH}_3}}{17.0\ \cancel{\text{g NH}_3}} \times \frac{22.4\ \text{L}}{1\ \text{mol}\ \cancel{\text{NH}_3}} = 2.55\ \text{L}$

(e) $351.3\ \cancel{\text{kg O}_3} \times \frac{1000\ \text{g}}{1\ \cancel{\text{kg}}} \times \frac{1\ \text{mol}\ \cancel{\text{O}_3}}{48.00\ \text{g}\ \cancel{\text{O}_3}} \times \frac{22.4\ \text{L}}{1\ \text{mol}\ \cancel{\text{O}_3}} = 1.64 \times 10^5\ \text{L}$

12.60 (b) 1.18×10^{-4} L (c) 5.57×10^{-3} L (d) 0.186 L

12.61 (a) $0.0304 \text{ L } N_2O \times \frac{1 \text{ mol } N_2O}{22.4 \text{ L } N_2O} \times \frac{44.0 \text{ g } N_2O}{1 \text{ mol } N_2O} = 0.0597 \text{ g } N_2O$

(c) $0.916 \text{ m}^3 \text{ } C_2H_2 \times \frac{1000 \text{ L}}{1 \text{ m}^3} \times \frac{1 \text{ mol } C_2H_2}{22.4 \text{ L } C_2H_2} \times \frac{26.0 \text{ g } C_2H_2}{1 \text{ mol } C_2H_2}$

$= 1.06 \times 10^3 \text{ g } C_2H_2$

(b) 241 g HCl (d) 0.09917 g UF_6 (e) 2.016×10^{-2} g Kr

12.62 First calculate the volume that the gas would occupy at STP. Then correct the volume to the stated conditions.

(b) $5.44 \text{ kg ClF} \times \frac{1000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mol ClF}}{54.5 \text{ g ClF}} \times \frac{22.4 \text{ L}}{1 \text{ mol ClF}} = 2.24 \times 10^3 \text{ L at STP}$

Solve the combined gas law for V_2.

$V_2 = V_1 \times (P_1/P_2) \times (T_2/T_1)$

$V_2 = 2.24 \times 10^3 \text{ L} \times \frac{760 \text{ torr}}{799 \text{ torr}} \times \frac{333 \text{ K}}{273 \text{ K}} = 2.60 \times 10^3 \text{ L}$

(a) 6.33×10^3 L (c) 4.10×10^{-7} L

12.64 (a) $\frac{1 \text{ mol } Cl_2}{22.4 \text{ L } Cl_2} \times \frac{70.9 \text{ g } Cl_2}{1 \text{ mol } Cl_2} = \frac{3.15 \text{ g } Cl_2}{\text{L } Cl_2}$

(b) $\frac{1 \text{ mol } CO_2}{22.4 \text{ L } CO_2} \times \frac{44.0 \text{ g } CO_2}{1 \text{ mol } CO_2} = \frac{1.96 \text{ g } CO_2}{\text{L } CO_2}$

(c) 5.86 g/L (d) 1.96 g/L (e) 6.67 g/L

12.65 (a) $P = nRT/V$

$P = \text{mol} \times \frac{\text{L} \times \text{atm}}{\text{mol} \times \text{K}} \times \frac{\text{K}}{1} \times \frac{1}{\text{L}} = \text{atm}$

(b) $n = PV/RT$

$n = \text{atm} \times \text{L} \times \frac{\text{mol} \times \text{K}}{\text{L} \times \text{atm}} \times \frac{1}{\text{K}} = \text{mol}$

(c) T = K (d) V = L

12.66 (a) $\frac{0.0821 \text{ L·atm}}{\text{mol·K}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = \frac{82.1 \text{ mL·atm}}{\text{mol·K}}$

(c) $\frac{0.0821 \text{ L·atm}}{\text{mol·K}} \times \frac{10 \text{ dL}}{1 \text{ L}} \times \frac{101325 \text{ Pa}}{1 \text{ atm}} \times \frac{1 \text{ kPa}}{1000 \text{ Pa}} = \frac{83.2 \text{ kPa·dL}}{\text{mol·K}}$

(b) 62.4 cm^3·torr/mmol·K (e) 0.0624 m^3·torr/mol·K

12.67 (a) Solving the ideal gas equation for V:

$V = nRT/P$

$V = 2.36 \text{ mol} \times \frac{0.0821 \text{ L·atm}}{1 \text{ mol·K}} \times 711 \text{ K} \times \frac{1}{1.73 \text{ atm}} = 79.6 \text{ L}$

12.67 (a) Using the factor-label method:

$$\frac{2.36\ \text{mol}}{1} \times \frac{711\ \text{K}}{1} \times \frac{1}{1.73\ \text{atm}} \times \frac{0.0821\ \text{L·atm}}{1\ \text{mol·K}} = 79.6\ \text{L}$$

(b) 3.62 L (c) 7.02 L

12.68 (b) Solving the ideal gas equation for n:

$n = PV/RT$

Change the given units to those that correspond to the units of the ideal gas constant.

$$V = 29.4\ \text{mL} \times \frac{1\ \text{L}}{1000\ \text{mL}} = 0.0294\ \text{L}$$

$$P = 397\ \text{kPa} \times \frac{1000\ \text{Pa}}{1\ \text{kPa}} \times \frac{1\ \text{atm}}{101325\ \text{Pa}} = 3.92\ \text{atm}$$

$$T = 273.15 + 9.06°\text{C} = 282.21\ \text{K}$$

$$n = 3.92\ \text{atm} \times 0.0294\ \text{L} \times \frac{1\ \text{mol·K}}{0.0821\ \text{L·atm}} \times \frac{1}{282.21\ \text{K}} = 0.00498\ \text{mol}$$

Using the factor-label method:

$$\frac{29.4\ \text{mL}}{1} \times \frac{1\ \text{L}}{1000\ \text{mL}} \times \frac{397\ \text{kPa}}{1} \times \frac{1000\ \text{Pa}}{1\ \text{kPa}} \times \frac{1\ \text{atm}}{101325\ \text{Pa}} \times \frac{1}{282.21\ \text{K}} \times \frac{1\ \text{mol·K}}{0.0821\ \text{L·atm}} = 0.00498\ \text{mol}$$

(a) 0.0112 mol (c) 0.0406 mol

12.69 (c) Solving the ideal gas equation for P:

$P = nRT/V$

Change the given units to those that correspond to the units of the ideal gas constant.

$$V = 1.08\ \text{dm}^3 \times \frac{1\ \text{m}^3}{10^3\ \text{dm}^3} \times \frac{1000\ \text{L}}{1\ \text{m}^3} = 1.08\ \text{L}$$

$$P = 0.00299\ \text{mol} \times \frac{0.0821\ \text{L·atm}}{1\ \text{mol·K}} \times 107.4\ \text{K} \times \frac{1}{1.08\ \text{L}} = 0.0244\ \text{atm}$$

Using the factor-label method:

$$\frac{1}{1.08\ \text{dm}^3} \times \frac{10^3\ \text{dm}^3}{1\ \text{m}^3} \times \frac{1\ \text{m}^3}{1000\ \text{L}} \times \frac{0.00299\ \text{mol}}{1} \times \frac{107.4\ \text{K}}{1} \times \frac{0.0821\ \text{L·atm}}{1\ \text{mol·K}} = 0.0244\ \text{atm}$$

(a) 14.8 atm (b) 24.2 atm

12.70 (a) Change the given units to those that correspond to the units of the ideal gas constant.

$$P = 743\ \text{torr} \times \frac{1\ \text{atm}}{760\ \text{torr}} = 0.978\ \text{atm}$$

$$T = 273.2 + 21.6°\text{C} = 294.8\ \text{K}$$

Find the number of moles of gas by solving the ideal gas equation for n.

$$n = PV/RT = 0.978\ \text{atm} \times 2.17\ \text{L} \times \frac{1\ \text{mol·K}}{0.0821\ \text{L·atm}} \times \frac{1}{294.8\ \text{K}} = 0.0877\ \text{mol}$$



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New Ways to Know

ISBN-13: 978-0-618-24301-
ISBN-10: 0-618-24301-1



UD-740-481

N00834